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EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD FOR 1960

THE ENVIRONMENTAL STUDIES AND EVALUATION STAFF

JUNE 1, 1961

HANFORD LABORATORIES

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD FOR 1960

By

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Radiation Protection Operation
Hanford Laboratories Operation

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RICHLAND, WASHINGTON

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EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD FOR 1960

I. INTRODUCTION

The Hanford project is a complex of nuclear reactors, fuel fabrication plants, chemical separation facilities and research and development laboratories.* The project is located in southeastern Washington as shown in Figure 1. This part of Washington is a semiarid region having an average annual rainfall of about 8 inches. Natural vegetation in the area is sparce, primarily suited for grazing although considerable areas have been put under irrigation. The plant site, shown in Figure 2, comprises an area of about five hundred square miles. The Columbia River flows through the area and forms the eastern boundary. The meteorology of the region is typical of a desert area with frequent strong inversions occurring at night, and breaking during the day to provide unstable and turbulent conditions. The prevailing winds are from the northwest in the plant areas with strong drainage and cross winds causing distorted flow patterns.

The populated areas of primary interest are Richland, Pasco, and Kennewick. Other communities in the vicinity are Benton City, Mesa, and Othello. Altogether, about 80,000 people live in the vicinity of the project.

During the course of its operation, the Hanford plant generates various radioactive wastes. High level wastes are concentrated and retained in storage within the project area. Low level wastes, for which concentration and retention are not presently feasible are admitted to the atmosphere, the Columbia River and to ground through controlled releases. The Hanford philosophy governing radioactive waste disposal is described in the Hearings on Industrial Radioactive Waste Disposal held by the Joint Congressional Committee on Atomic Energy in 1959.[1]

Radioactive wastes dispersed to the atmosphere and to the Columbia River may contribute to the radiation exposures of persons living in the neighborhood of the plant or along the Columbia River downstream from the plant. The protection of these persons from undue radiation exposure attributable to Hanford sources is one of the attendant responsibilities in the operation of the Hanford facilities.

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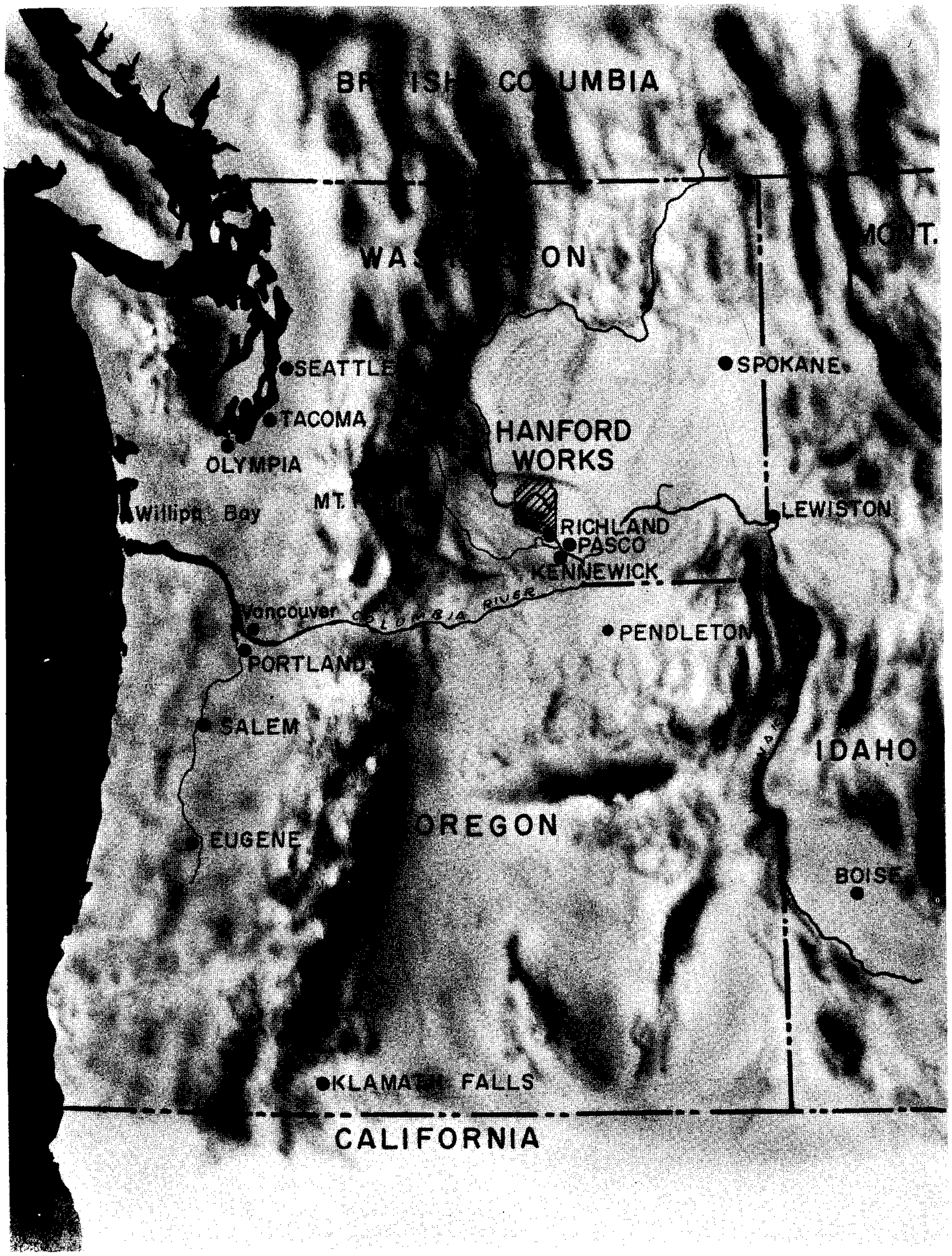

FIGURE 1

Geographical Relationship of Hanford Works to the Pacific Northwest

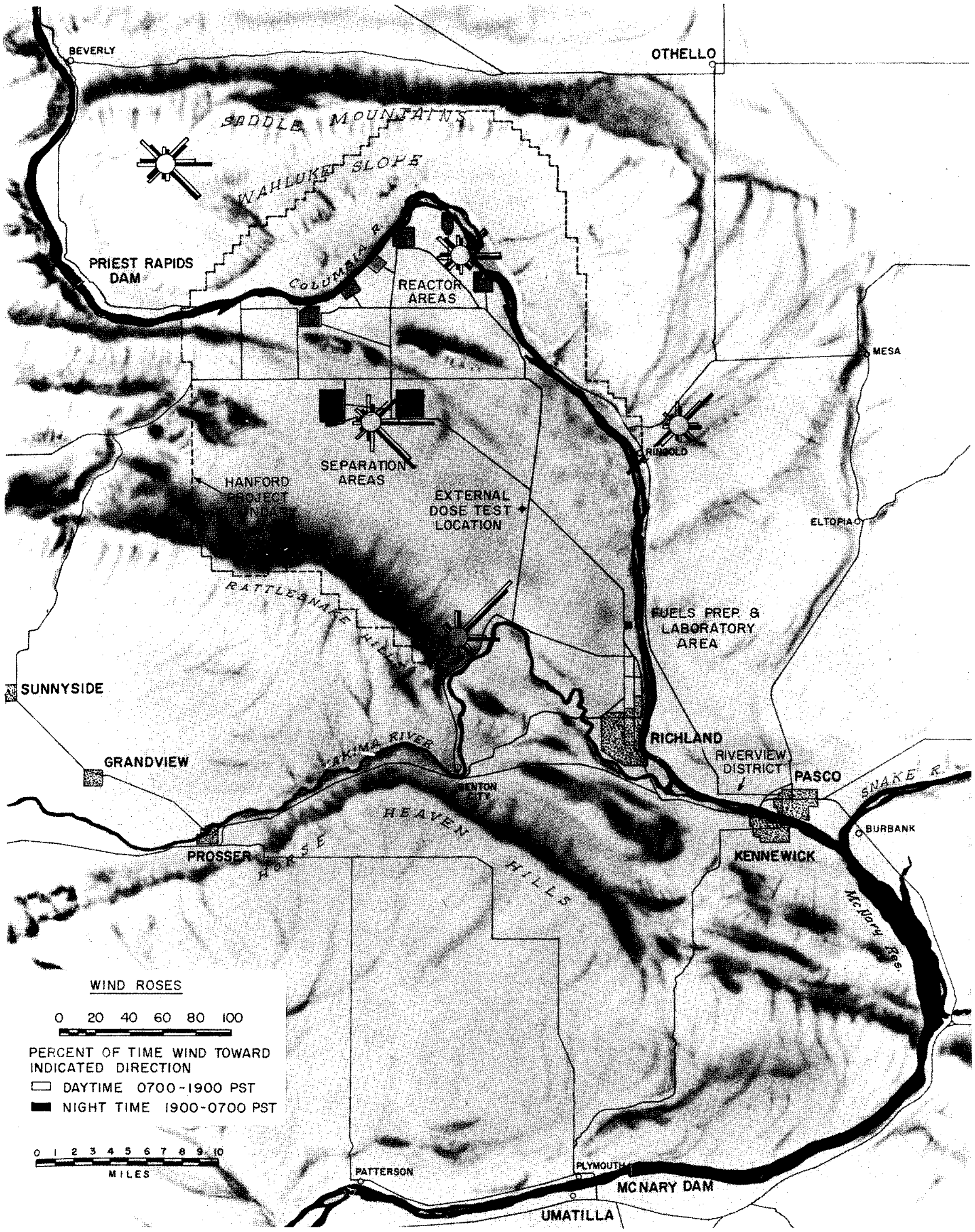

FIGURE 2

Features of Hanford Project and Vicinity

The recommendations of the National Committee on Radiation Protection and Measurements, the International Commission on Radiological Protection, the Federal Radiation Council, and the results of local research programs form the basis of standards used in assessing the degree of environmental radiation protection needed and attained. The effectiveness of waste control and radiation protection practices is determined by comparison of the evaluated results from the Hanford environmental monitoring program with the reference standards.

The presentation and evaluation of the results of the environmental radiation protection program for the year 1960 is the subject of this report. Similar evaluations for previous years have been reported.[1, 2]

II. SUMMARY

The results of the Hanford environmental monitoring program for 1960 are presented in detail. The measurement results are summarized and evaluations are made in terms of exposures and other effects.

The principal Hanford source of exposure to persons in the neighborhood of the controlled area is identified with the neutron induced radionuclides present in reactor cooling water discharged to the Columbia River. The primary mechanisms of exposure from this source are the drinking of sanitary water derived from the river and the consumption of fish and waterfowl which inhabit the river. Hanford's contribution to environmental exposure through atmospheric paths is generally less than that due to fallout from nuclear detonations.

Many variables, such as multiple sources, paths of intake, individual diets, periods of occupancy, and so forth, complicate expression of environmental exposure. Potential exposures are, however, calculated for hypothetical persons based on plausible assumptions on sources, diets, etc. For such individuals whose habits include ingestion of Pasco sanitary water, ingestion of local fish and waterfowl, and consumption of produce from local farms, the data suggest an intake of bone-seeking radionuclides of about 40 per cent of that recommended by the NCRP as maximum for continuous intake by individuals in the neighborhood of controlled areas. For those persons who drink Pasco water but who do not routinely eat fish or waterfowl from the Columbia River, the exposure appears to be on the order of 5 per cent of the recommended maximum, (in this case to the GI tract).

For individuals who make no use of the Columbia River or products derived therefrom, the intake of bone seekers is estimated as about 3 per cent of the recommended maximum--the bulk of which was due to world wide fall-out.

Comparison of measurement results for 1960 with those of 1959 indicate that no significant change occurred in the radiological conditions in the vicinity of Hanford.

III. ENVIRONMENTAL MONITORING PROGRAM RESULTS AND INTERPRETATION

Discussion and interpretation of the results of the various Hanford environmental sampling programs follow. Data for many of the programs are presented in the appendices, as are brief descriptions of several of the analytical methods used in determining the amounts of radionuclides in various samples.

A. Reactor Effluent Released to the Columbia River

Cooling water for each of Hanford's eight production reactors is pumped from the Columbia River. This water goes through water purification processes and then passes once through the reactors as coolant. Although the coolant water is treated to remove suspended impurities, a fraction of the impurities remaining are transformed into radioactive elements during passage through the reactor and during retention in films which form on the surface of the fuel channels and elements. Very small quantities of uranium in the cooling water undergo fission during passage through the reactor and form small amounts of fission product radionuclides. Occasionally fuel element jackets will fail releasing small amounts of fission products to the cooling water. After it has passed through the reactor the cooling water, (reactor effluent water) is returned to the Columbia River.

Twenty radionuclides, formed principally by neutron activation, make up 98 per cent of the radioactive material present in reactor effluent. Over forty others, which have been measured with some confidence, make up the remaining two per cent of the activity. The relative abundance of these radionuclides, as adjusted to four hours post irradiation, is shown in Table I.

TABLE I

RELATIVE ABUNDANCE OF REACTOR EFFLUENT RADIONUCLIDES

Reference Time - 4 hrs. Post Irradiation

Major (90%)	Minor (8%)	Trace (2%)		
Mn^{56}	Zn^{69}	Eu^{152}	I^{131}	Pr^{145}
Cu^{64}	Ga^{72}	Sm^{153}	Ce^{141}	Pm^{151}
Na^{24}	Sr^{92}	W^{187}	Pr^{142}	Co^{60}
Cr^{51}	U^{239}	La^{141}	C^{14}	Pr^{143}
Np^{239}	I^{133}	Nd^{149}	Nd^{147}	Ru^{103}
As^{76}	Y^{92}	La^{140}	Ca^{45}	Sc^{47}
Si^{31}	Nb^{97}	I^{132}	Ag^{111}	Sr^{90}
	Sr^{91}	Eu^{157}	Y^{91}	Cs^{137}
	Zn^{65}	Ba^{140}	Fe^{59}	Sr^{85}
	P^{32}	Mo^{99}	Sr^{89}	U^{238}
	Y^{90}	Sm^{156}	Mn^{54}	Pu^{239}
	I^{135}	Sc^{46}	Zr^{95}	Ac^{227}
	Y^{93}	Cd^{115}	Pm^{149}	Po^{210}
		Ce^{143}	Eu^{156}	Tb^{160}
		Pm^{147}	$Ce\text{-}Pr^{144}$	

There are several ways by which radionuclides in the Columbia River water may result in radiation exposure to humans. Among these paths of exposure are ingestion of Columbia River water, ingestion of sanitary water derived from the river, ingestion of fish and waterfowl which inhabit the river, consumption of agricultural and dairy products derived from land irrigated with water drawn from the river, consumption of certain marine organisms, and external exposure from swimming, boating, etc. on the river.

B. Radionuclides in the Columbia River

Samples of river water were obtained weekly from the inlet of the Pasco municipal water pumping plant, and biweekly at the Hanford Ferry and Vancouver monitoring stations. These samples were analyzed for several radionuclides and the results of the analyses are presented in Appendix A, Tables 3, 4 and 9.

Many of the radionuclides formed in reactor cooling water are short-lived and decay rapidly after formation in the reactors. In addition to radioactive decay, a significant fraction of the radionuclides is removed from the water by such mechanisms as silting and uptake by river biota.

The relative abundance of the significant radionuclides at Hanford Ferry, Pasco and Vancouver is illustrated in Figure 3. The areas of the charts are proportional to the total activity measured at the three locations. The average concentrations of radionuclides measured routinely at the three river sampling stations are also shown in Table II.

TABLE II

ANNUAL AVERAGE CONCENTRATION OF SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER - 1960

Units of 10^{-9} $\mu c/cc$

Radionuclide	Hanford Ferry	Pasco	Vancouver
Total Beta	50,000	11,000	580
RE+Y	3,800	1,400	26
Na^{24}	2,800	1,500	-
Si^{31}	1,000	-	-
P^{32}	380	200	41
Sc^{46}	65	35	~ 18
Cr^{51}	10,000	5,600	2,100
Mn^{56}	14,000	-	-
Cu^{64}	14,000	2,000	-
Zn^{65}	560	300	75
As^{76}	4,800	1,500	-
Sr^{89-90}	13	6.3	3.2
Sr^{90}	0.6	0.6	0.4
I^{131}	32	12	~ 4
Np^{239}	7,000	3,300	135
Zn^{69m}	750	100	-
Ga^{72}	510	99	-

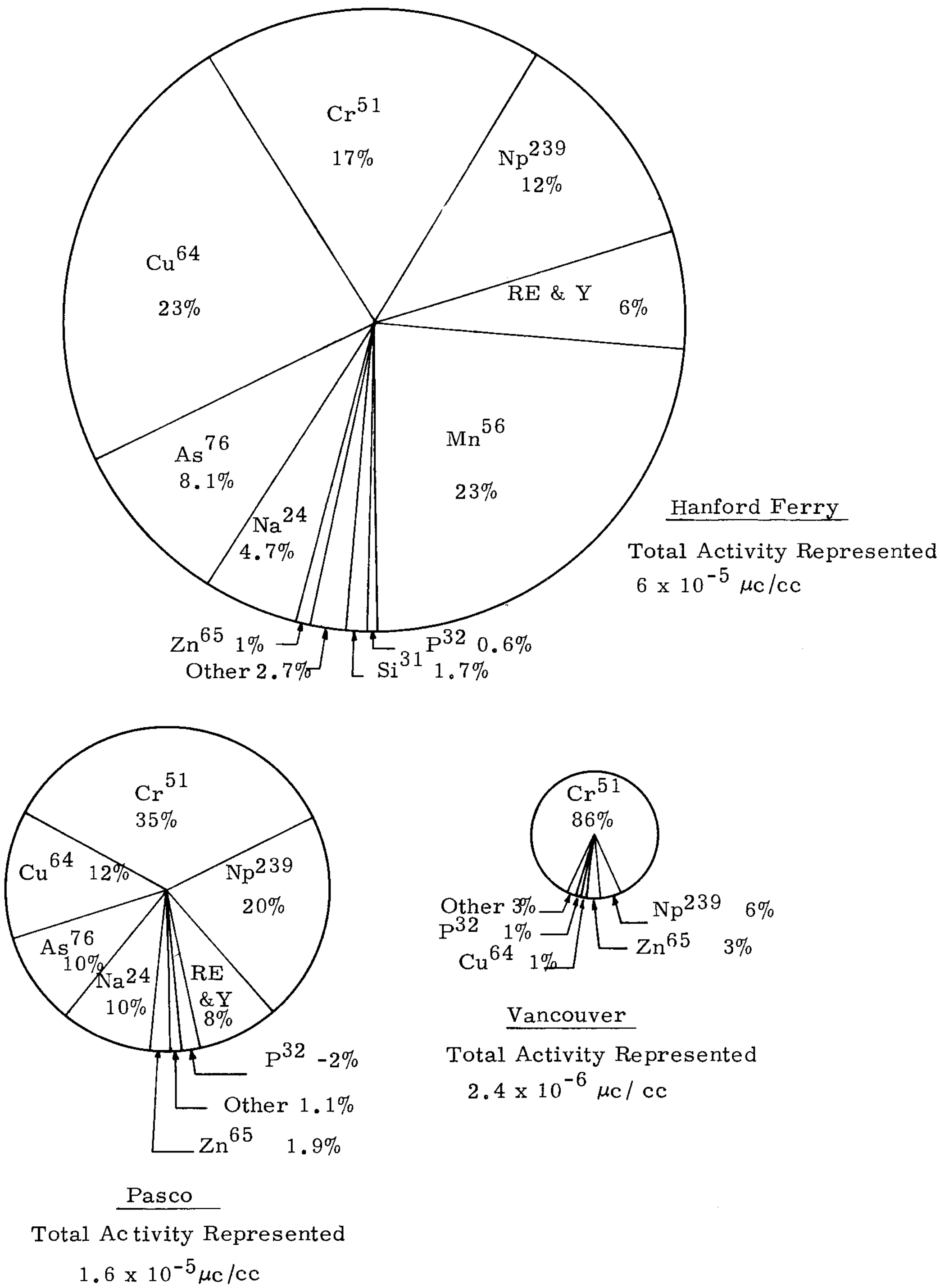

FIGURE 3

Relative Abundance of Radionuclides at Several Locations
Annual Averages 1960

The Hanford Ferry monitoring station is about seven miles downstream from the reactors and about six miles upstream from the point where the project boundary crosses the Columbia River. The results shown would be slightly higher than those obtained at the project boundary, the first point of potential use. The reactor effluent plume is not uniformly distributed across the river at this location and measurement results would vary both across the river and with depth.

The Pasco water plant monitoring station is at the point of first municipal usage of the Columbia River and is about 40 miles downstream from the reactors. The distribution of radioactive material in the river is not uniform at Pasco due, in part, to the entry of the Yakima River some 10 miles upstream from Pasco. The Yakima influent tends to make concentrations of radionuclides lower on the Kennewick side of the river.

Vancouver is the farthest downstream location where river water is routinely sampled and is about 260 miles from the reactors. Further downstream nearer the mouth of the river the salt content of the water complicates quantitative measurement of the radionuclides and tidal movement increases variability of results.

The seasonal variation in flow rate of the Columbia River markedly effects the dilution of the reactor effluent. Also effected is the time taken for a given volume of water to move from one location to another which in turn affects depletion. The seasonal variation of flow rate of the Columbia River at Pasco and Vancouver is illustrated in Figure 4. The variation in concentration of several radionuclides in the Columbia River water at Pasco, Washington for 1960 is illustrated in Figure 5.

Although there is no known routine human consumption of untreated river water, the potential radiation exposure from such a source may be of interest. The calculated annual dose to the gastrointestinal tract and total body and the combined percentages of maximum permissible (MPRI)* rate of intake for bone seekers are presented in Table III.

* The maximum permissible rate of intake (MPRI) is taken as the maximum permissible concentration in water for a given radionuclide, as recommended by the NCRP for persons in the neighborhood of controlled areas, multiplied by the rate of water intake as defined for the standard man.(3) This amounts to one-tenth of the MPC's for continuous exposure of occupational workers multiplied by 2,200 cc/day.

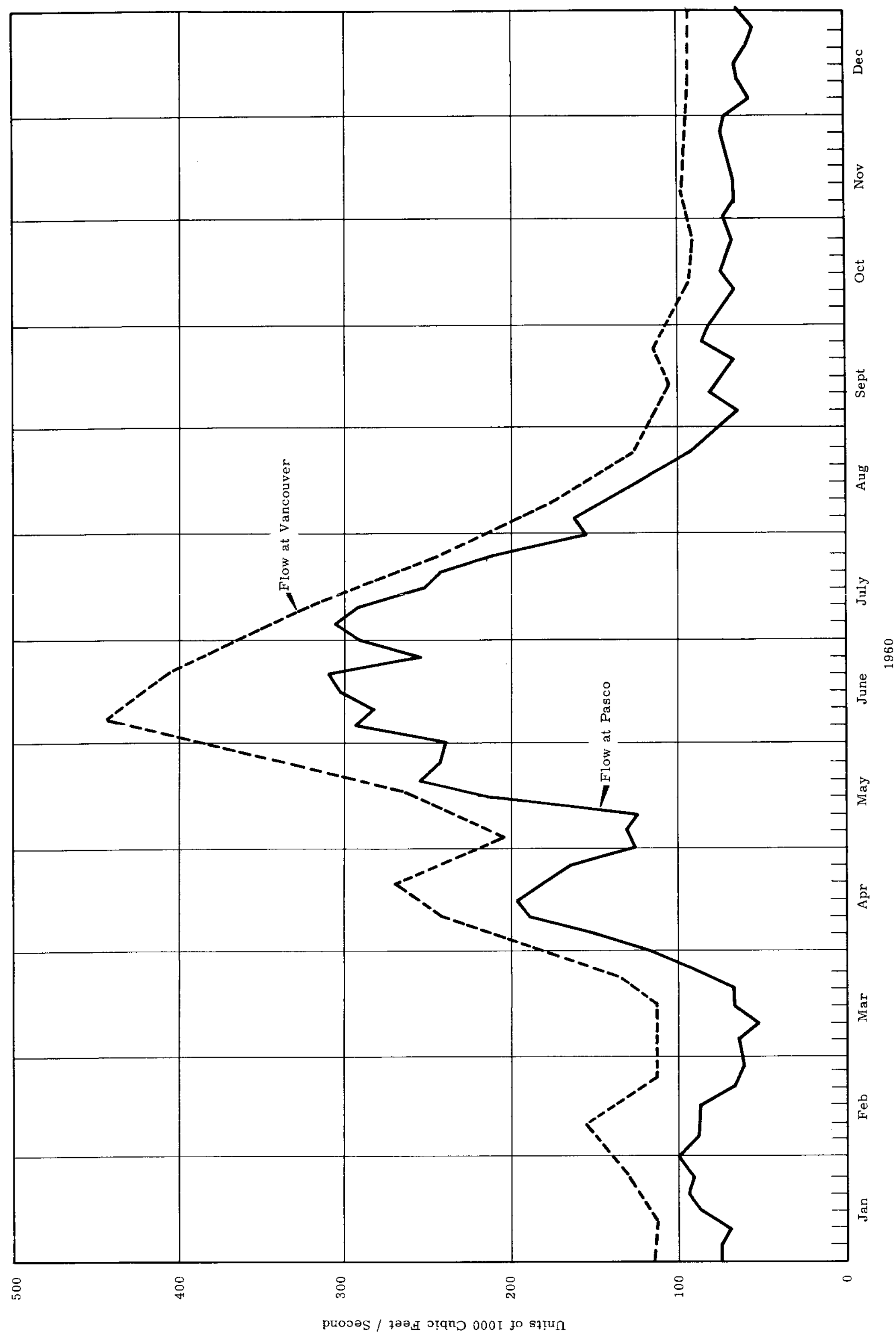

FIGURE 4

Columbia River Flow at Pasco and Vancouver - 1960
From Data Published by the U. S. Geological Survey

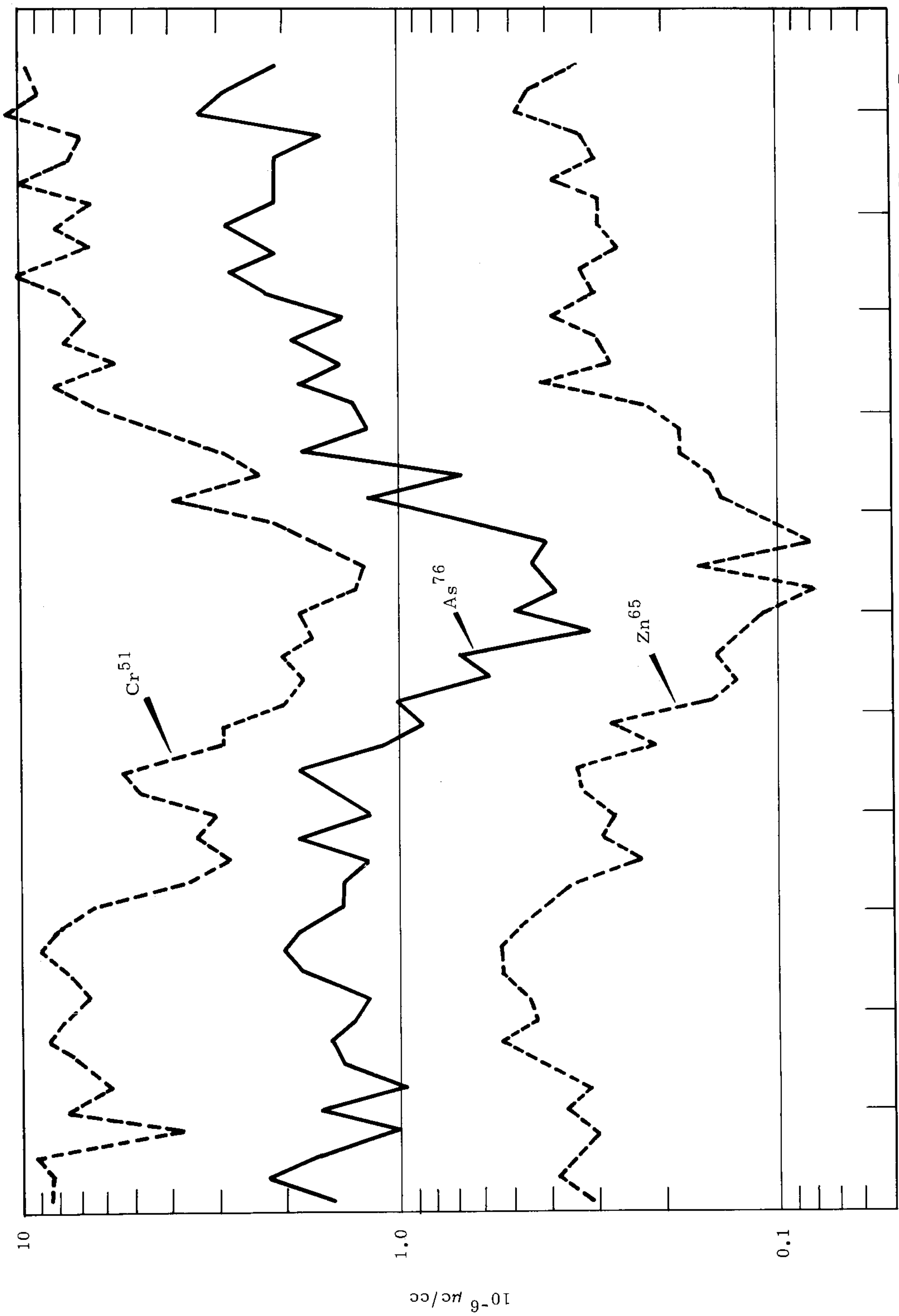

FIGURE 5

Variation in Concentration of Selected Radionuclides in Columbia River Water at Pasco, Washington for 1960

TABLE III

ANNUAL DOSE TO SELECTED ORGANS FROM ROUTINE INGESTION OF COLUMBIA RIVER WATER AT SEVERAL LOCATIONS - 1960

	Mrems Total Body	Mrems GI-Tract	% MPRI Bone
Columbia River Water at Hanford Ferry	10	980	2.1
Columbia River Water at Pasco	5	260	1.6
Columbia River Water at Vancouver	2	8	0.7

C. Radionuclides in Sanitary Water

Pasco and Kennewick are the nearest of the few cities downstream from the plant which treat Columbia River water for use as sanitary water. Sanitary water from each of the water treatment plants was sampled weekly and analyzed for radionuclides. The results of radioanalysis of water from these plants are presented in Appendix A, Tables 1 and 2.

In both cities, the sanitary water samples were collected near the water treatment plants. Because there is a significant flow time between the point of sampling and most consumers, the concentrations of short-lived nuclides in the water at the time it is consumed is less than that shown. The decay time available varies from hours to days depending upon water usage rates, particular location of the consumer, etc.

Table IV shows the apparent efficiency of the water treatment plant at Pasco for the removal of various radionuclides.

TABLE IV

DEPLETION OF SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER FROM TREATMENT AT THE PASCO WATER PLANT (1960 AVERAGES)

	% Depletion
RE+Y	82
Cu^{64}	82
As^{76}	73
P^{32}	70
Zn^{65}	60
Na^{24}	53
Np^{239}	42
Cr^{51}	15

These data include the radioactive decay of the radionuclides during travel through the water treatment plant. Table V presents the calculated annual average dose to the GI-tract and total body and the % MPRI for bone from sustained consumption of sanitary water at Pasco and Kennewick.

TABLE V

CALCULATED ANNUAL EXPOSURE OF SELECTED ORGANS FROM ROUTINE INGESTION OF SANITARY WATER

	Mrems Total Body	Mrems GI-Tract	% MPRI Bone
Pasco	2	80	0.8
Kennewick	1	16	0.5

The potential contribution of several radionuclides in river water and Pasco sanitary water to the calculated annual dose to the GI-tract is illustrated in Figure 6. The short term and seasonal variations in GI-tract dose at Pasco are illustrated in Figure 7.

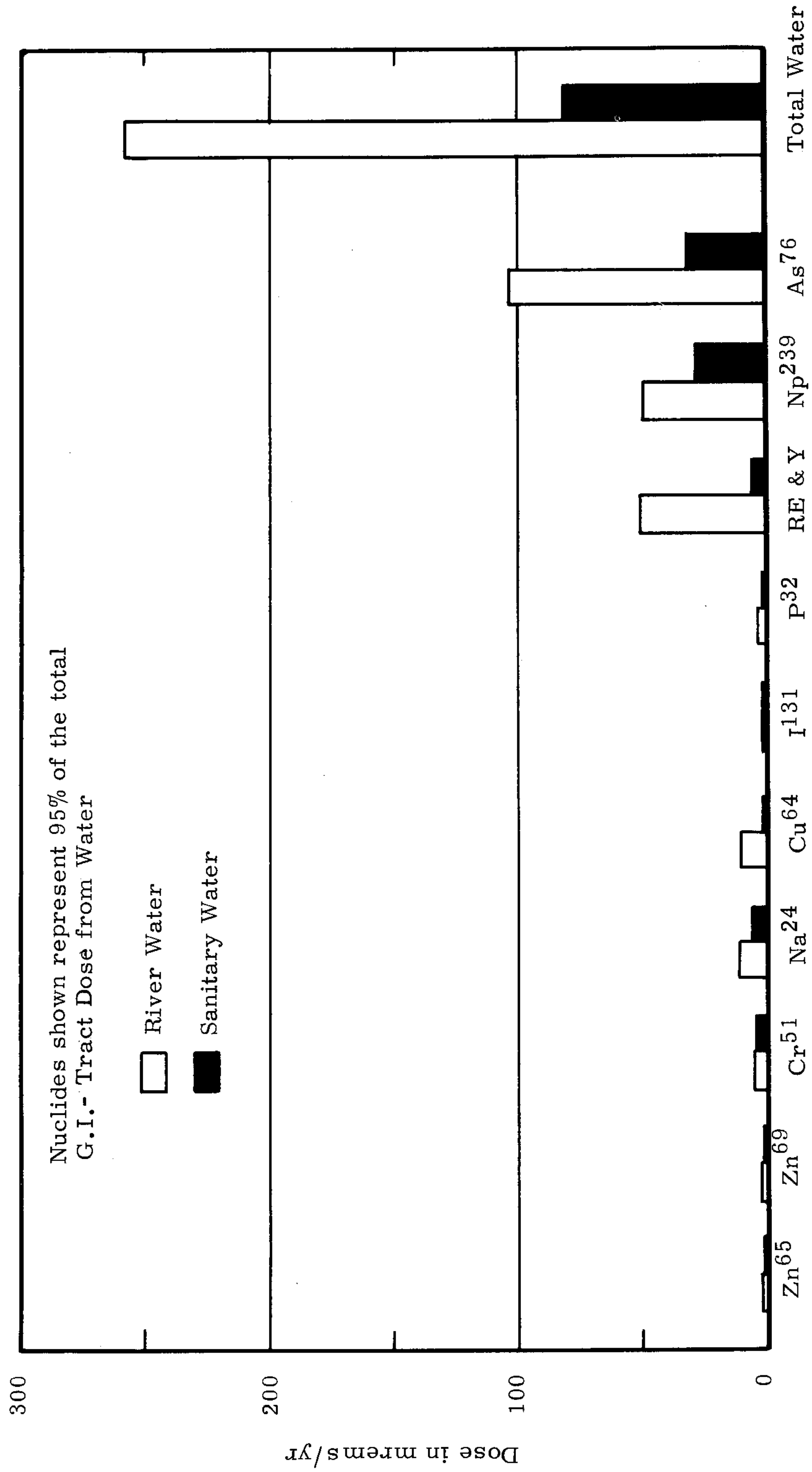

FIGURE 6

Contribution of Selected Radionuclides to Calculated Dose to the G.I. Tract From Columbia River or Sanitary Water at Pasco, Washington 1960

AEC-GE RICHLAND, WASH.

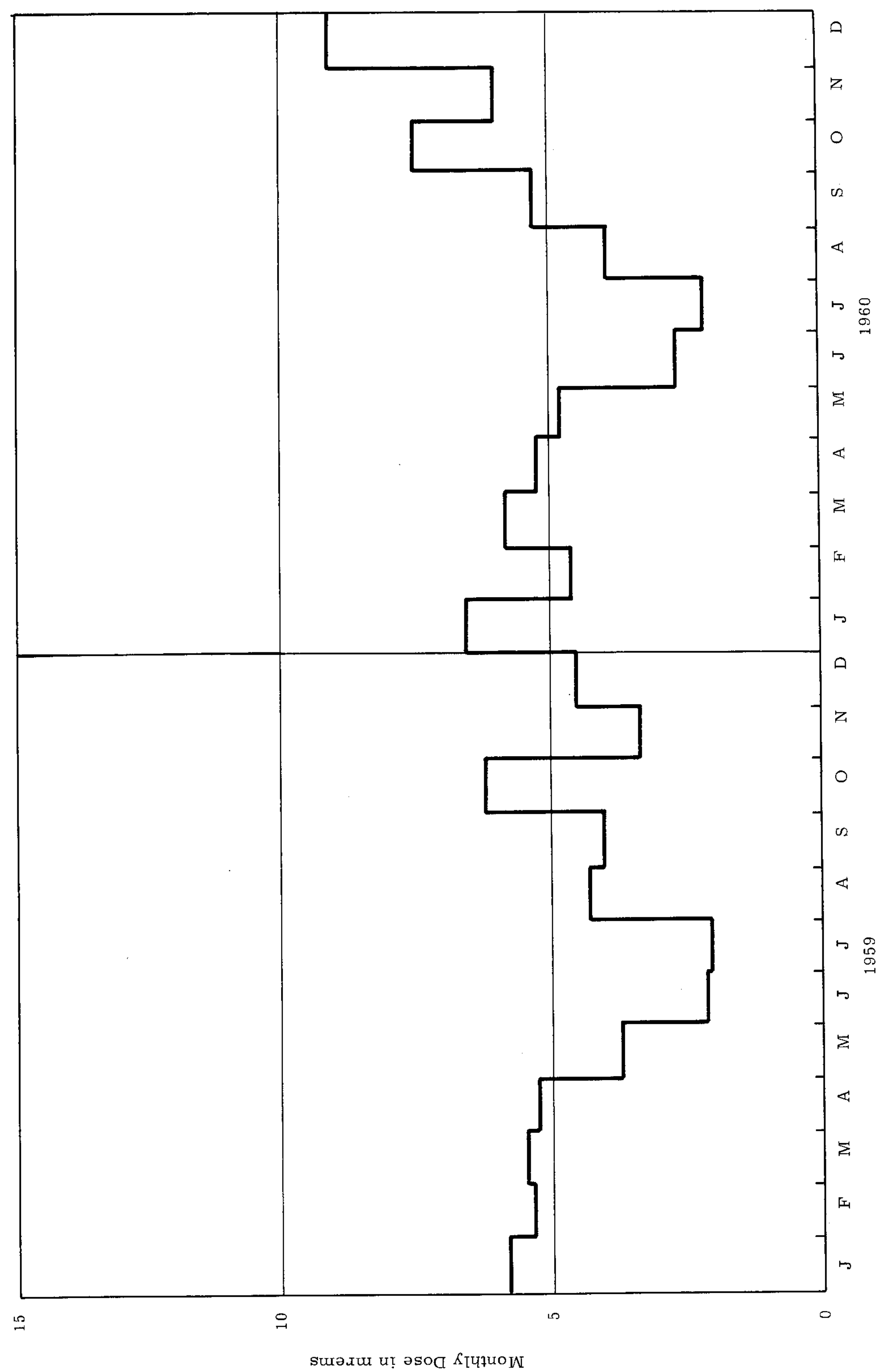

FIGURE 7

Monthly Average G.I. Tract Dose From Routine Ingestion of Pasco Sanitary Water 1959-1960

D. Radionuclides in Fish and Waterfowl

Species of fish which feed in the Columbia River downstream from the reactors accumulate some of the radionuclides present in reactor effluent water. Except for suckers, whitefish usually have the greatest concentration of radioactive materials. The bulk of this material is P^{32} which deposits principally in the bone but is also found in the flesh. The average concentration of P^{32} in the flesh of whitefish sampled at Ringold, the closest fishing area available to the public downstream from the reactors, reached a seasonal maximum of 3×10^{-3} μc/g in the fall of 1960.

From the observed seasonal trends in the concentration of P^{32} during 1960 it is estimated that a consumption of ten pounds of fresh whitefish over a twelve-month period would result in an intake of about 5 μc P^{32}. This would provide an estimated exposure of about 100 mrems to the GI-tract, 40 mrems to the total body and about 30 per cent of the maximum permissible rate of intake of P^{32} for bone.

Hunting for waterfowl is not permitted within the Hanford reservation nor within a quarter of a mile of the Columbia River in this part of the state. An exception to this is a special hunting area below the mouth of the Snake River on the McNary Game Range. Migratory waterfowl such as mallard ducks, Canada geese, etc., which have utilized the Hanford section of the river may contain radionuclides and may be harvested by hunters at a number of places. During the 1960 waterfowl hunting season, samples from about 600 ducks bagged by hunters of the local area were scanned for radionuclides.[4] About 40 per cent of these contained detectable amounts of radioactive materials. Less than 15 per cent of the samples contained concentrations of P^{32} approximating that of the whitefish.

Results of the 1960 biological monitoring program, conducted by the Radioecology Operation, which pertain to the environmental program are presented in Appendix A, Table 6. Measurements made during the last few years at Ringold and Hanford Ferry are shown in Figure 8. The variability of individual results for fish within a catch is illustrated in Figure 9.

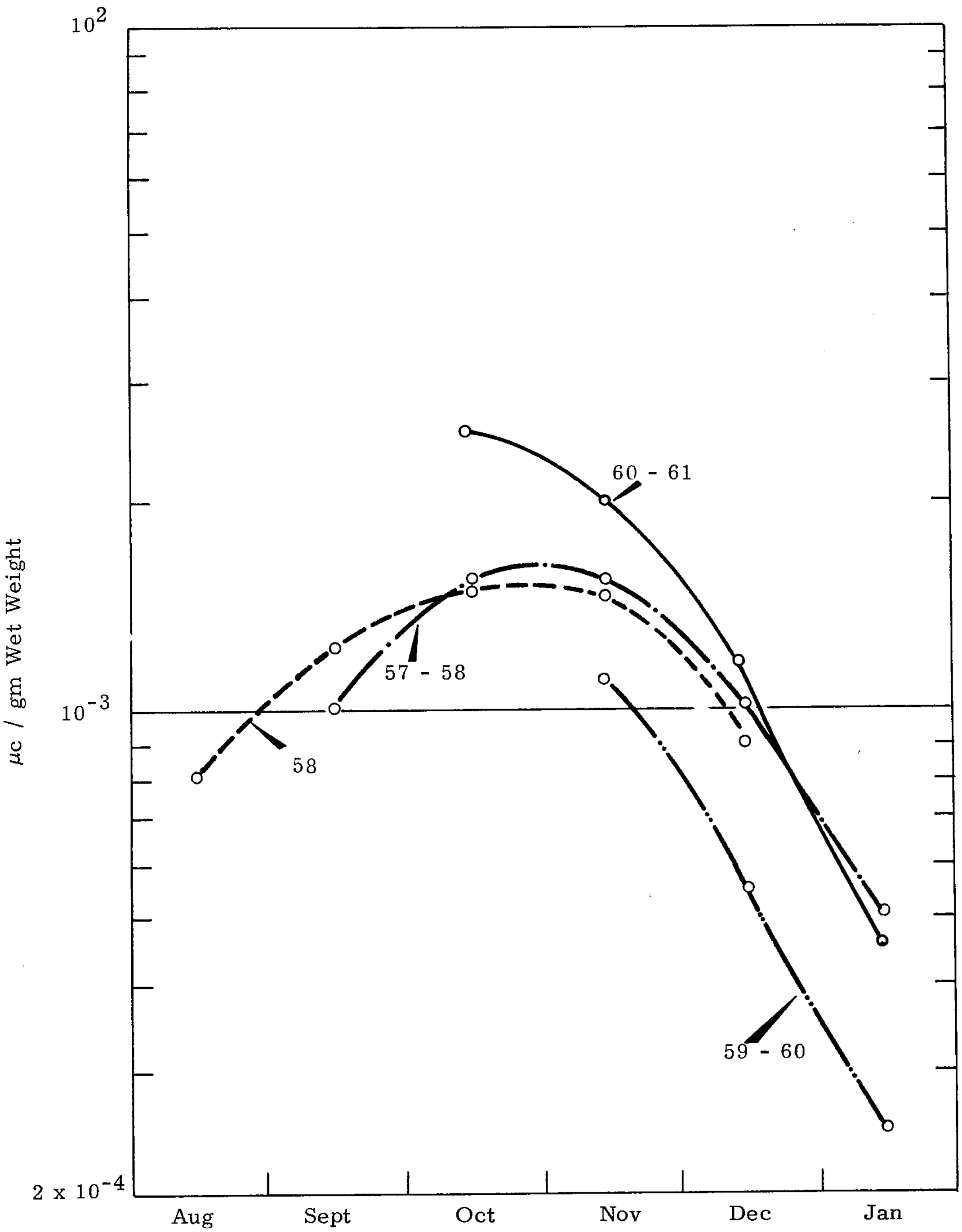

FIGURE 8

Average Concentrations of Beta Emitters in Muscle of White Fish Collected From Vicinity of Ringold and Hanford Ferry

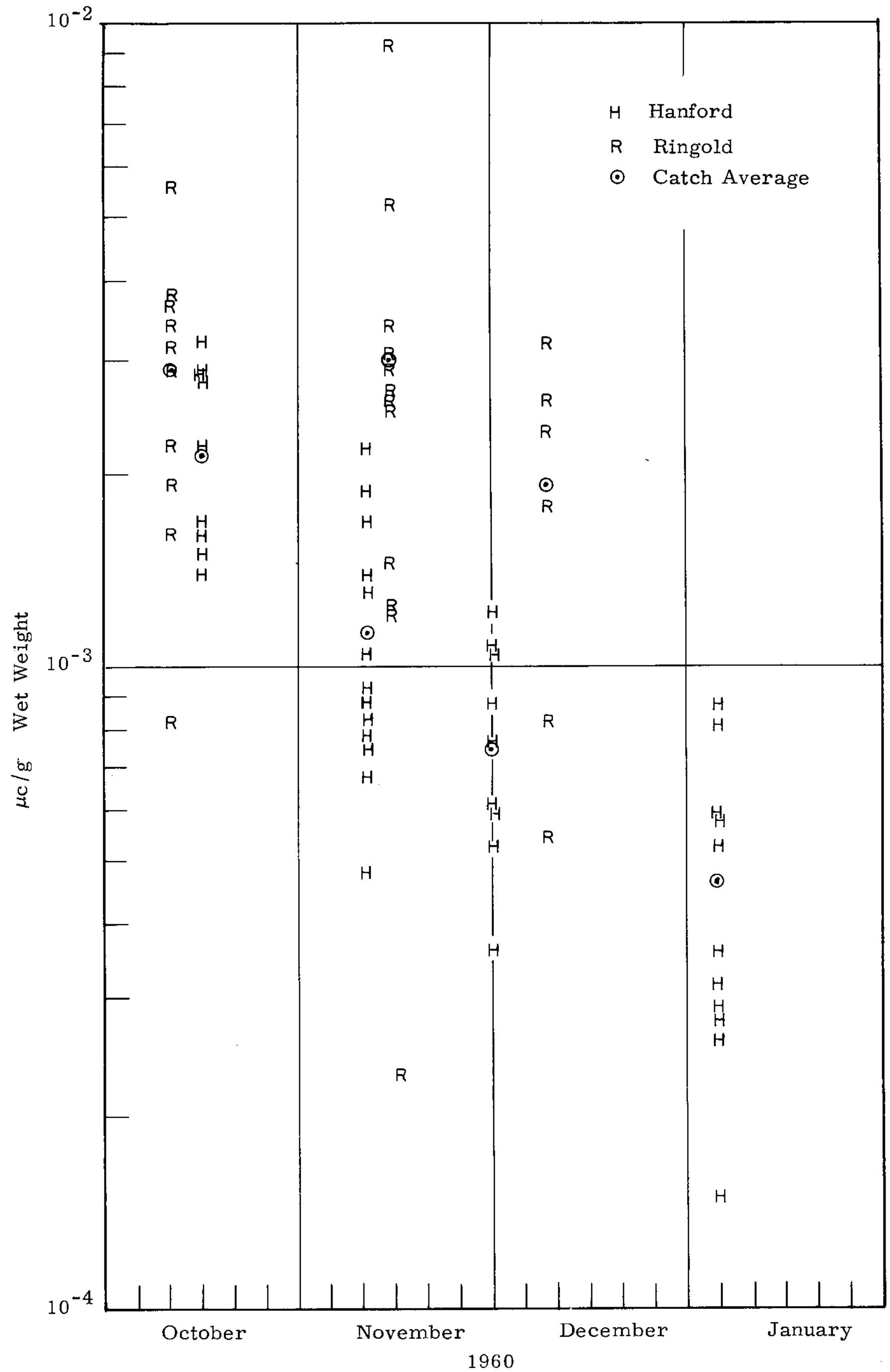

FIGURE 9

Concentrations of Beta Emitters in Muscle of White Fish Collected Near Ringold and Hanford Ferry

E. Radionuclides Entering the Pacific Ocean

The rate of transport of radionuclides past Vancouver may be used as an index of the quantities of certain radionuclides entering the Pacific Ocean from the Columbia River. The annual average rate of transport of selected radionuclides is given in Table VI.

TABLE VI

ANNUAL AVERAGE RATE OF TRANSPORT OF SELECTED RADIONUCLIDES PAST VANCOUVER - 1960

Radionuclides	Curies/day
P^{32}	17
Cr^{51}	850
Zn^{65}	38
Np^{239}	72

An equilibrium exists in the ocean for these radionuclides in the sense that the rate of addition through the river system corresponds to the rate of decay of the radionuclides which have previously entered the Ocean. If a constant rate of entry into the Ocean equivalent to that indicated by the Vancouver data is assumed, then the equilibrium values amount to: ~360 curies of P^{32}, ~240 curies of Np^{239}, ~ 33,000 curies of Cr^{51} and ~14,000 curies of Zn^{65}.

F. Radionuclides in Marine Organisms

Zinc-65 is a radionuclide of reactor effluent origin which has been found in sufficient abundance beyond the mouth of the Columbia to be of radiological interest. Samples of oysters grown in Willapa Bay were obtained on six occasions and analyzed for Zn^{65} and other radionuclides. The results of these measurements are presented in Appendix C, Table 4. The average Zn^{65} concentration found was about 5×10^{-5} μc/g of oysters which is substantially the same as that observed in 1959. Consumption of oysters containing this amount of Zn^{65} at a sustained rate of one pound each week would lead to a dose to the total body of about 7 mrems per year which may be compared with the exposure from natural background radiation which is usually taken as 100 mrems per year.

G. Recreational Use of the Columbia River - External Exposure

Since the Columbia River is used for swimming, water skiing and boating downstream from Hanford, measurements of penetraing radiation in the river were made. These measurements were made with "pencil-type" ionization chambers placed in bottles and submerged in the river. The average dose rate measured in the river during the months of April through October in the vicinity of Richland was 1.4 mr/day; upstream near the Laboratories and Fuel Preparation Area 1.9 mr/day; and near Kennewick 1.0 mr/day. The dose rate on land averages about 0.4 mr/day. Assuming a person spends 240 hours a year on the river in the vicinity of Richland he would have received about 15 mr from this source.

H. Radioactive Wastes Released to the Atmosphere

Air-borne radioeffluents at Hanford are primarily associated with process vessel off-gases and building ventilation air from the chemical separations facilities. This gaseous waste is released to the atmosphere through 200 foot-high stacks after removal of some 99 per cent of the radioactive materials present. Under normal operating conditions the ventilation air from reactor and laboratory buildings contain comparatively minor amounts of radioactive materials.

The radionuclide of principal interest in process off-gases is I^{131}. Continuous measurements of the release of I^{131} from the separations facilities are made. Results of such measurements are presented in Table 21, Appendix B. The average daily emission rates of I^{131} and several other radionuclides for the year are shown in Table VII.

TABLE VII

AVERAGE EMISSION RATES OF SEVERAL RADIONUCLIDES FROM SEPARATIONS PLANT STACKS - 1960

Radionuclide	Average Emission c/day
I^{131}	1.0
$Zr\text{-}Nb^{95}$	0.01
Ru^{103}	0.007
Ru^{106}	0.006
Ce^{141}	0.001

Earlier measurements indicated that emission rates of the rare earth and yttrium group was about 0.02 c/day; Sr^{89} about 0.004 c/day and Sr^{90} about 0.0005 c/day.

Air-borne radioactive material can contribute to human exposure through such pathways as inhalation, ingestion of leafy vegetables upon which the material has deposited, and milk from cows which have grazed on affected pasture.

I. Radioactive Particulates in the Atmosphere

Filter papers from air sampling stations at the Hanford Project, Richland, Yakima, Walla Walla, Spokane, Lewiston, Boise and Klamath Falls, (See Figure 1), were changed on a weekly frequency by cooperating agencies. These filters were analyzed for the number of radioactive particles and for total beta activity. Measurement results of beta activity on filter samples are presented in Appendix B, Table 2. These results for 1959 and 1960 are illustrated in Figure 10.

Over the past several years, most of the radioactive material picked up on filters of the above network of air sampling stations has been of fallout origin from nuclear detonations. Prior to October of 1959 the filters from the Hanford station usually contained less radioactive material than filters from regions with greater rainfall. With the moratorium on weapons testing, the quantity of fallout material found on the filters has gradually diminished. Except for the Hanford station, the decline has continued to the present. The average for the Richland station for 1960 was about 1×10^{-13} μc total beta per cc of air filtered, which is in good agreement with results reported by the U. S. Public Health Service Radiation Surveillance Network for August 1960.[5] At the Hanford station, however, the level has remained at about 2×10^{-13} μc per cc since October of 1959.

J. Concentrations of I^{131} in Air

Measurements of I^{131} concentrations in air are made routinely at several communities adjacent to the plant. Results of these measurements for 1960 are presented in Appendix B, Table 3 and are summarized in Table VIII.

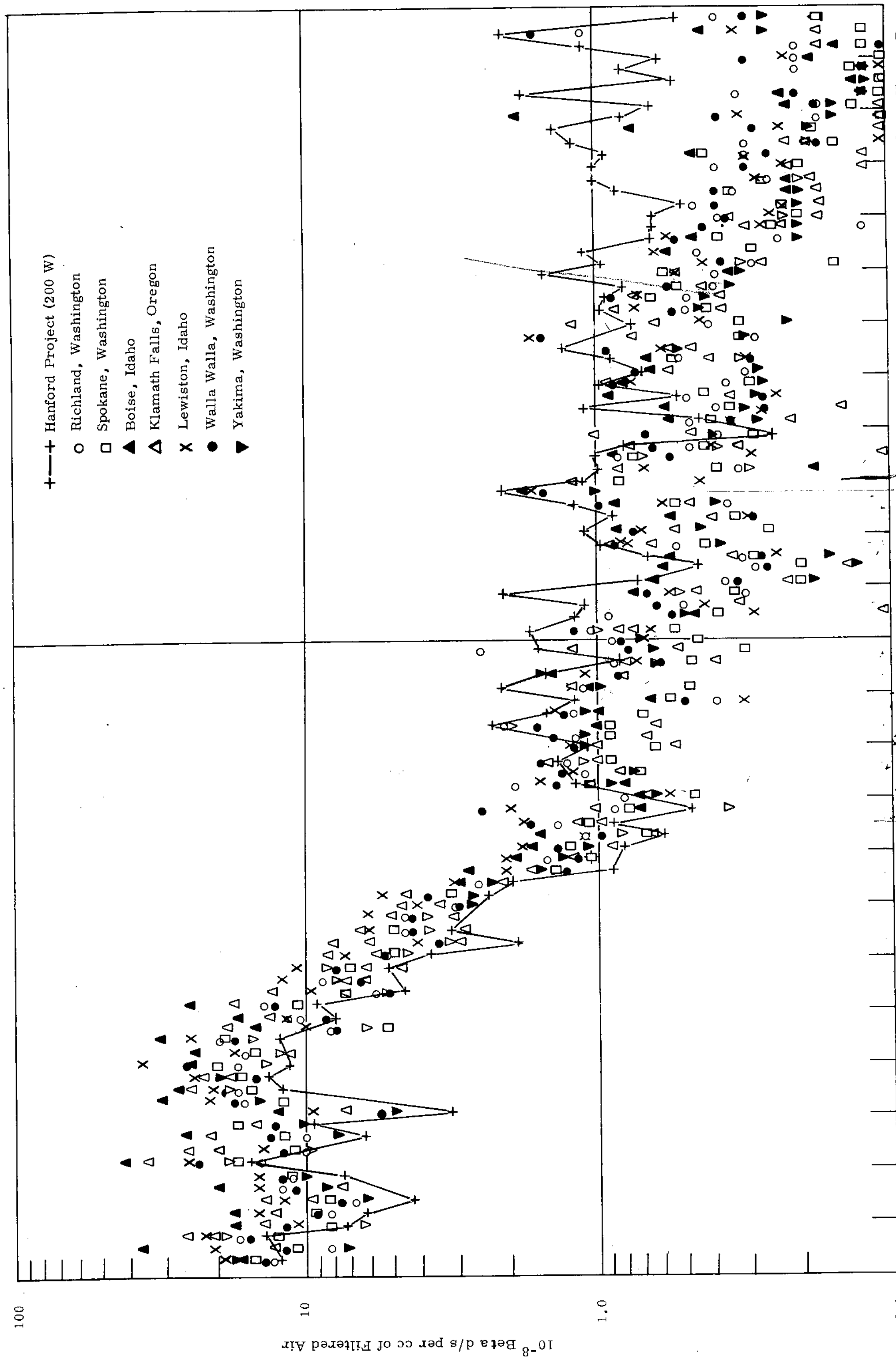

FIGURE 10

Activity on Filters From Selected Northwestern United States Sampling Locations

TABLE VIII

AVERAGE IODINE-131 CONCENTRATIONS IN ATMOSPHERE

Location	Distance from Separations Stacks	Concentrations in units of 10^{-14} μc/cc		Calculated Thyroid Dose in Millirads	
		1959	1960	1959	1960
Benton City	20 mi	15	5.4	1.5	0.6
North Richland	21 mi	6.4	4.3	0.6	0.4
Richland	23 mi	7.9	3.0	0.9	0.3
Pasco	32 mi	13	2.3	1.2	0.2

The communities listed above lie within a 45° sector southeast to south of the point of emission.

K. Radionuclides in Native Vegetation

Some of the radioactive material released to the atmosphere is deposited on the ground or on vegetation as local fallout. This radioactive material can be transferred to man or animals through ingestion of such vegetation or through ingestion of milk derived from animals grazing on such vegetation. As a consequence of this exposure potential the environmental monitoring program at Hanford includes sampling of native grasses on the Hanford reservation and at off-project locations such as Portland, Spokane and Lewiston. The sampling area is divided into zones as indicated in Figure 11.

The sampling procedure consisted of collecting 15 grams of grass at each of ten sites throughout a zone. Composited samples were analyzed by a gamma energy spectrometer for $Zr\text{-}Nb^{95}$, $Ce^{141+144}$, $Ru^{103+106}$, I^{131} and $Ba^{140}\text{-}La^{140}$. The results of vegetation measurements for off-project zones are presented in Appendix B, Tables 4 through 20.

Figure 12 illustrates the variation in concentrations of several radionuclides during 1959 and 1960 for Spokane and Vicinity (Zone T) as representative of outlying zones. Figure 13 is typical of on-plant zones located within about 15 miles of the separations facilities stacks.

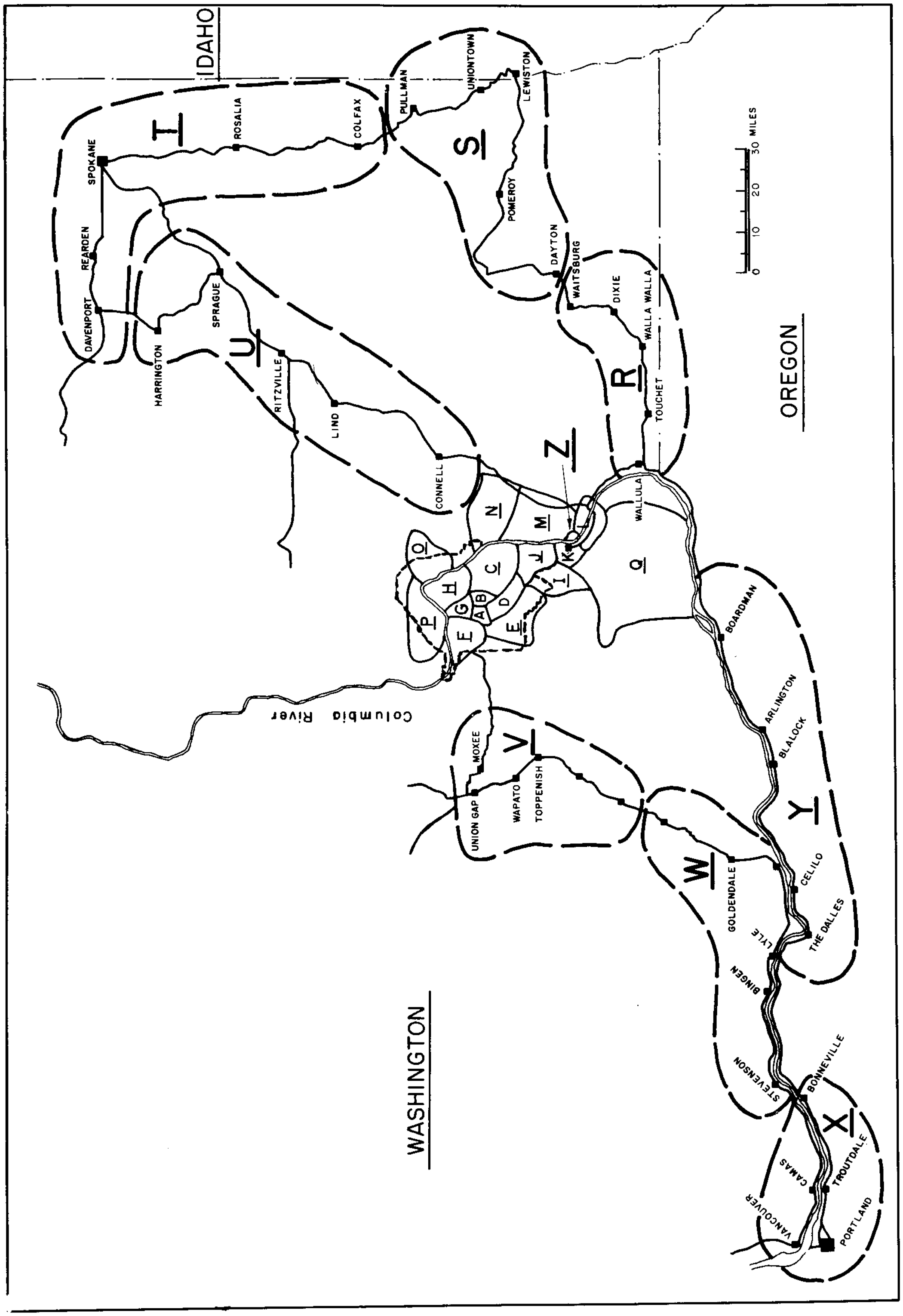

FIGURE 11

Vegetation Sampling Zones - Hanford Project and Vicinity

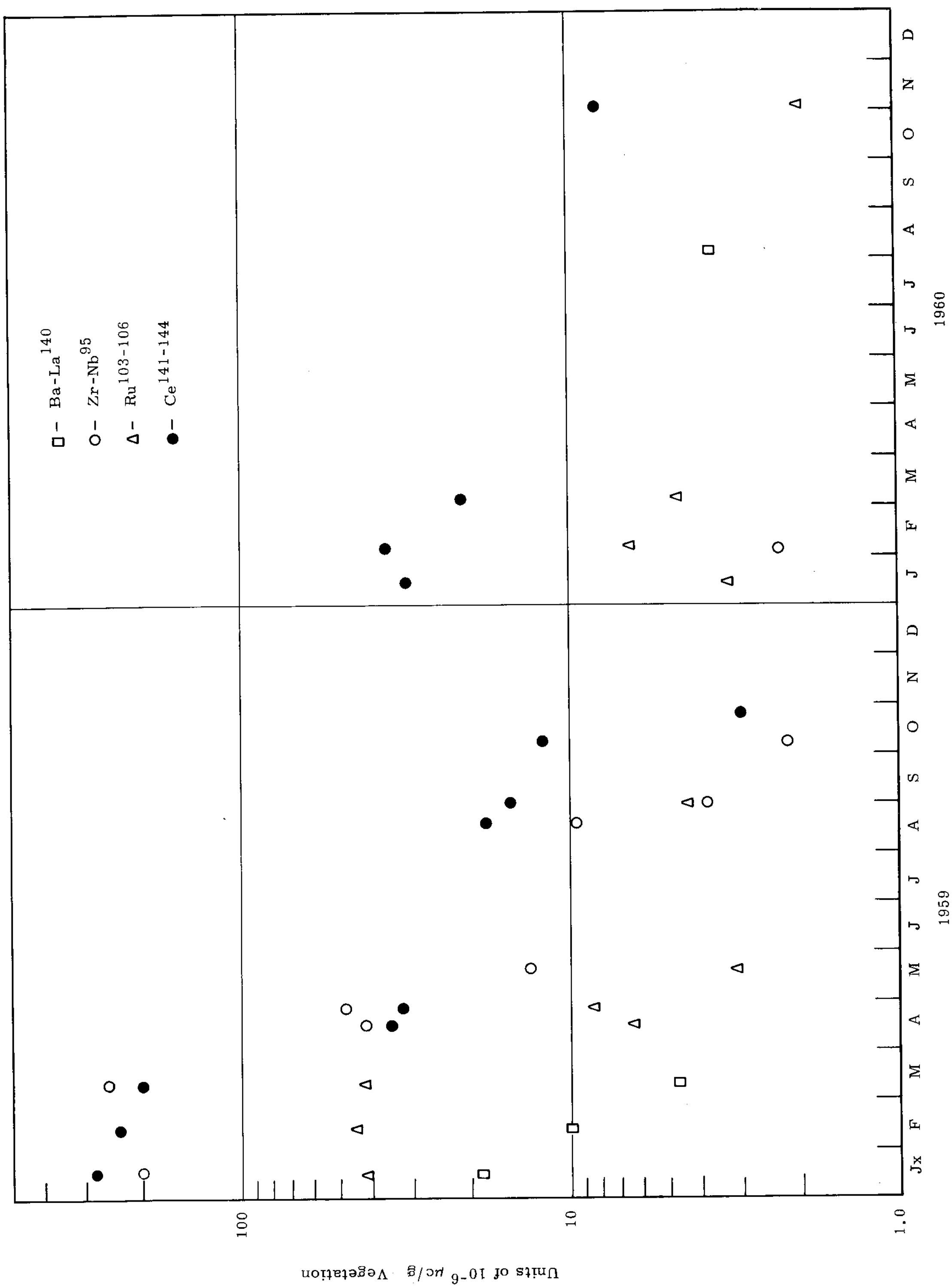

FIGURE 12

Radionuclide Concentration on Native Vegetation - Spokane and Vicinity (1959 and 1960)

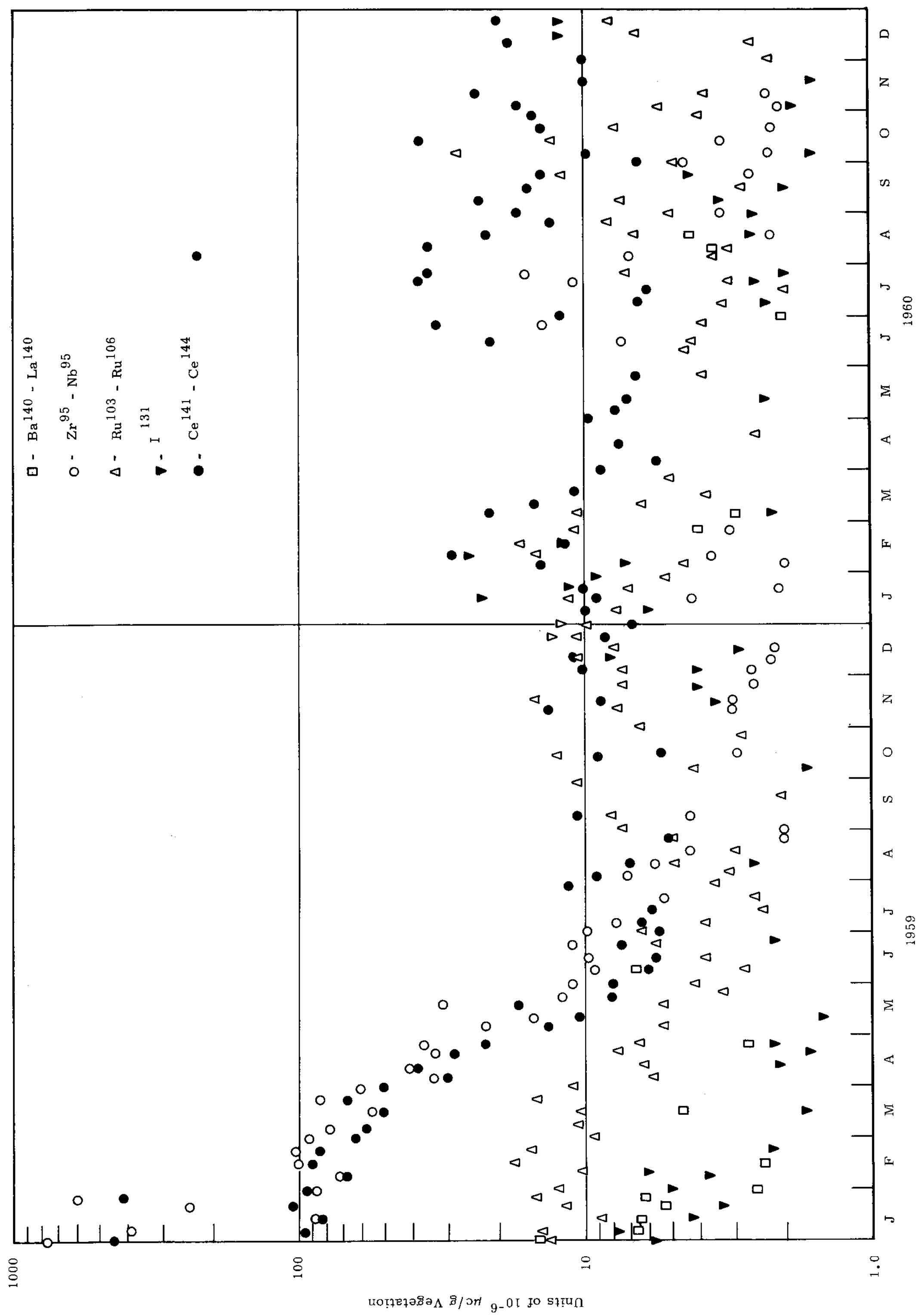

FIGURE 13
Radionuclide Concentration on Native Vegetation Zone C (1959 and 1960)

The criterion for release of I^{131} is locally based on uptake by vegetation and subsequent exposure of range animals as well as humans.[6] The local control limit derived on this basis is 1×10^{-5} μc/g of vegetation. Since this control is based on chronic ingestion, concentrations in excess of this limit for short periods of time do not necessarily indicate conditions of concern.

Figure 14 illustrates the measurement results of I^{131} on native vegetation for all off-project zones in 1960. Significant concentrations of I^{131} on vegetation beyond the project boundaries were not anticipated at the average release rate of 1 c/day and none were found.

In Figure 15, the Iodine-131 concentrations on vegetation are shown for the zone immediately adjacent to one of the stacks. In this same figure, the daily stack emission data have been summed, corrected for half-life and plotted as "quantity available" according to the following equation:

$$C_o = (C_o\text{-}1)\, f + C_e$$

C_o = total quantity available on day of interest

C_o-1 = total quantity available on day preceding day of interest

$f = e^{-.0845} = 0.919$ decay factor

C_e = curies emitted on day of interest.

L. Concentrations of I^{131} in Beef Cattle Thyroids

Late in 1960 assay of thyroids of cattle slaughtered for beef at Pasco, Washington was initiated. Since the concentration of I^{131} in the thyroids is expected to be several orders of magnitude higher than in the vegetation grazed or in milk, it may become advantageous to estimate concentrations of I^{131} in milk and on leafy vegetables from the thyroid levels when the former are otherwise too low for practical measurement. Additionally, knowledge of cattle thyroid exposure may be developed from the thyroid data.

The measurements of I^{131} in beef cattle thyroids made in 1960 are presented in Appendix B, Table 22. The average concentration in the 48 thyroids processed was 3×10^{-5} μc I^{131}/g, the maximum was 1×10^{-3} μc/g and the minimum was less than 1×10^{-6} μc/g. Extensive biological research

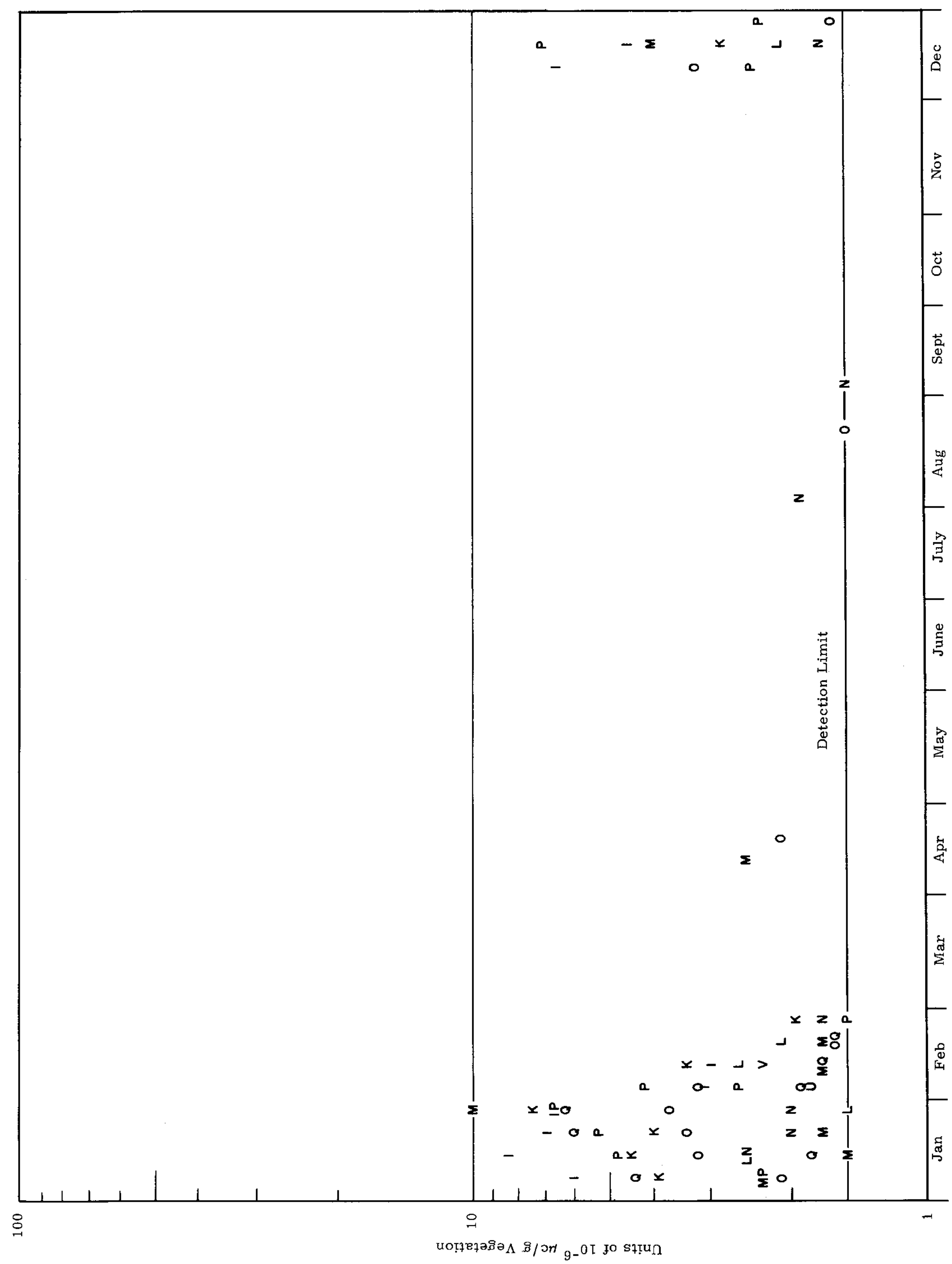

FIGURE 14

I^{131} In Native Vegetation - All Off Project Zones - 1960 (See Figure 11)

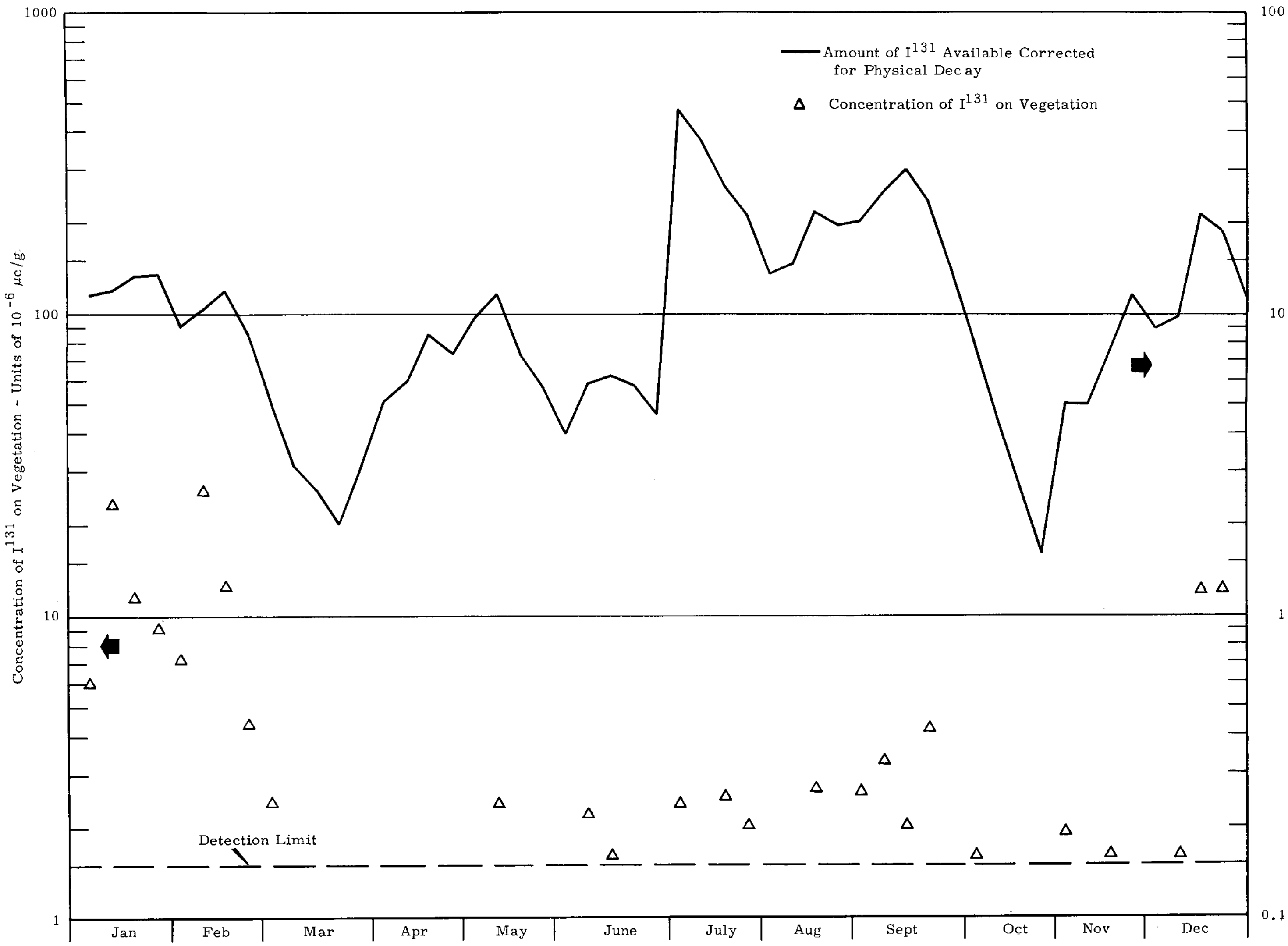

FIGURE 15

Comparison of I^{131} Deposition on Vegetation in the Vicinity of a Separations Facility (Zone C) with I^{131} Available - 1960 work at Hanford has shown that no detectable damage to sheep results from chronic I^{131} concentrations in the thyroid of less than about 0.04 μc/g.[7] Similar research work has not been carried out on cattle.

M. Radionuclides in Milk and Agricultural Produce

The radioactivity of local agricultural produce can be influenced by deposition of air-borne radionuclides on the ground or vegetation or by irrigation of food and forage crops with water containing reactor effluent radionuclides. Generally, the local source of air-borne radionuclides is considered to be the chemical separations facilities; however, under certain conditions the ventilation stacks of the reactors or laboratory areas could become the source of interest.

There is no farming within about a 20-mile radius of the separations facilities and under most meteorological conditions this distance affords good dilution before the radioactive effluents reach farming areas. Most of the irrigated land in the vicinity of the Hanford plant is irrigated from the Yakima River, or with water taken out of the Columbia above the project. The Ringold farms and the Riverview Irrigation District, which are about 15 and 30 miles downstream from the reactors, respectively, do take irrigation water from the Columbia, however, and produce from these limited areas is sampled regularly. These areas are about 20 miles east and 30 miles southeast, respectively, of the chemical separations facilities, (See Figure 1). Another area frequently sampled is the Benton City area on the Yakima River, about 20 miles south of the separations facilities.

Milk is routinely sampled at the Ringold, Riverview and Benton City locations. Commercial brands of milk available locally are also sampled at frequent intervals.

Experience of 1958 and 1959 suggested that under normal plant operating conditions vegetables and fruit contain very small quantities of radionuclides. A small amount of sampling was done in 1960 to re-affirm this conclusion. There was no culinary treatment given to the samples in preparation for analysis. Some removal of radioactive substances during washing, peeling, etc. would be expected if the produce was being prepared for human consumption.

Multichannel gamma energy spectrometry was used to analyze the samples for the following radionuclides: K^{40}, Sc^{46}, Cr^{51}, Zn^{65}, Zr^{95}-Nb^{95},

$Ru^{103+106}$, I^{131}, Cs^{137} and $Ce\text{-}Pr^{144}$. Analysis for P^{32}, Sr^{89} and Sr^{90} was accomplished through radiochemical separation and beta counting as described in Appendix F.

The preceding radionuclides are not all of those potentially present in foodstuffs but are those which are either anticipated from Hanford's radioeffluents or fallout and are radiologically significant.

In tabulating the data, reference is often made to reporting limits. These reporting limits reflect some of the uncertainties of gamma energy spectra measurement of a radionuclide in the presence of other gamma emitters. Thus the reporting limit is generally higher for any particular radionuclide than the detection limit would be if the radionuclide were the only one present.

Zinc-65 and P^{32} occurred in milk originating from areas irrigated with Columbia River water. The concentrations of Zn^{65} and P^{32} found in milk are given in Appendix C, Table 1 and are summarized in Table IX.

TABLE IX

AVERAGE CONCENTRATIONS OF ZN^{65} AND P^{32} IN MILK

Location	No. Samples	Zn^{65} $10^{-6}\mu c/g$	No. Samples	P^{32} $10^{-6}\mu c/g$
Ringold	24	0.63	20	1.3
Riverview 2	25	0.53	24	0.46
Riverview 3 (Jan., Feb. only)	5	0.39	-	-

Radionuclides usually associated with fallout, such as Sr^{90}, were found in most milk samples. The concentration of Sr^{89} and Cs^{137} in milk analyzed at Hanford was usually below 4×10^{-9} μc Sr^{89}/g and 3×10^{-8} μc Cs^{137}/g. The maximum values observed were 7×10^{-9} μc Sr^{89}/g and 1×10^{-7} μc Cs^{137}/g. The results for Sr^{90} and Cs^{137} are summarized in Table X.

TABLE X

AVERAGE CONCENTRATIONS OF Sr^{90} AND Cs^{137} IN MILK

Units of 10^{-6} $\mu c/g$

Location or Brand	No. Samples	Sr^{90}	No. Samples	Cs^{137}
Ringold	20	0.0030	24	< 0.034
Riverview 2	27	0.0038	25	< 0.033
Riverview 3	5	0.0056	5	< 0.030
Benton City 1	3	0.0033	5	< 0.030
Benton City 2	3	0.0027	1	< 0.030
Commercial A	4	0.0046	4	< 0.031
Commercial F	7	0.0032	8	< 0.030
Commercial H	7	0.0097	5	0.041

Other radionuclides for which a determination was made in commercial milk were: Sc^{46}, Zn^{65}, $Zr\text{-}Nb^{95}$, $Ru^{103+106}$, I^{131}, Cr^{51}, $Ce\text{-}Pr^{144}$, P^{32} and Sr^{89}. These results were below their respective reporting limits.

The absence of detectable quantities of Zn^{65} and P^{32} in commercial milk is probably due to the small fraction of milk contributed by the local farms to the total commercial milk supply. With the exception of milk obtained from local farms which are irrigated with Columbia River water, the radionuclide content of milk available in the Tri-City area appears typical of that reported by the U. S. Public Health Service in their Radiological Health Data Quarterly Reports for sections of the country with similar rainfall.[(5)]

At a consumption rate of one liter of milk per day the "fallout" nuclides would contribute an average annual dose of <1 mrem to the GI-tract, 2 mrems to the total body and 1.5 per cent of the maximum permissible rate of intake for bone. The additional exposure to the few individuals drinking milk from the Ringold area is calculated as 10 mrems to the GI-tract, 4 mrems to the total body and 2 per cent of the maximum permissible rate of intake for bone.

Milk was analyzed for I^{131} and most of the results indicated a concentration of less than the reporting limit of 5×10^{-8} μc I^{131}/g. Of the

twenty-four samples taken at Ringold, four contained I^{131} in excess of 5×10^{-8} μc/g milk. The largest number of positive analyses and a maximum of 1×10^{-7} I^{131}/g were found in samples from this area. The annual average concentrations of I^{131} in Ringold milk was between 1.5×10^{-8} μc/g and 5.5×10^{-8} μc/g, depending on whether results below the detection limit are considered to contain no I^{131}, or the amount of the detection limit (5×10^{-8} μc/g). At a consumption rate of 1 liter milk/day, a thyroid uptake of 30 per cent, an annual average concentration of I^{131} in milk as stated above and with sustained consumption over one year, the dose to the thyroid of standard man (20 g) would amount to 0.01 to 0.04 rad/yr.
≈ 10 – 40 mrem/yr.

N. External Radiation

A program for measurement of low level "background" radiation was conducted during 1960. A measurement location was established near one of the less used project roads about 9 miles southeast from the nearest chemical separation facility and about 8 miles northwest from the laboratories area. (External Dose Test Location - See Figure 2)

Several dose measuring instruments of the "stray radiation chamber" and "pencil ionization chamber" type were used at this location. The stray radiation chambers were used in groups of 5 placed on 3 foot stakes and exposed from two to five days. Several sets of 10 "pencil type" chambers were similarly exposed over different time periods. Since the stray radiation chambers seemed to be less affected by weather conditions, their measurements were chosen to illustrate the radiation levels observed.

Average chamber readings taken during 1960 are shown in Figure 16 and are tabulated in Appendix D. The annual average daily dose rate computed from these data amounted to 0.36 mr/day. The annual penetrating dose 3 feet above the ground at this location is, then, about 140 mr. Although background radiation varies from place to place, 140 mr/yr is taken as the estimated external dose from penetrating radiation in the vicinity of the Hanford project. This estimate is exclusive of exposure received while swimming or boating in the Columbia River.

O. Radioactive Wastes Released to Ground

Chemical separations processes account for nearly all of the liquid and solid radioactive waste sent to ground.

Solid wastes involving small quantities of radionuclides are packaged, placed in trenches and buried. At these arid burial locations, moisture

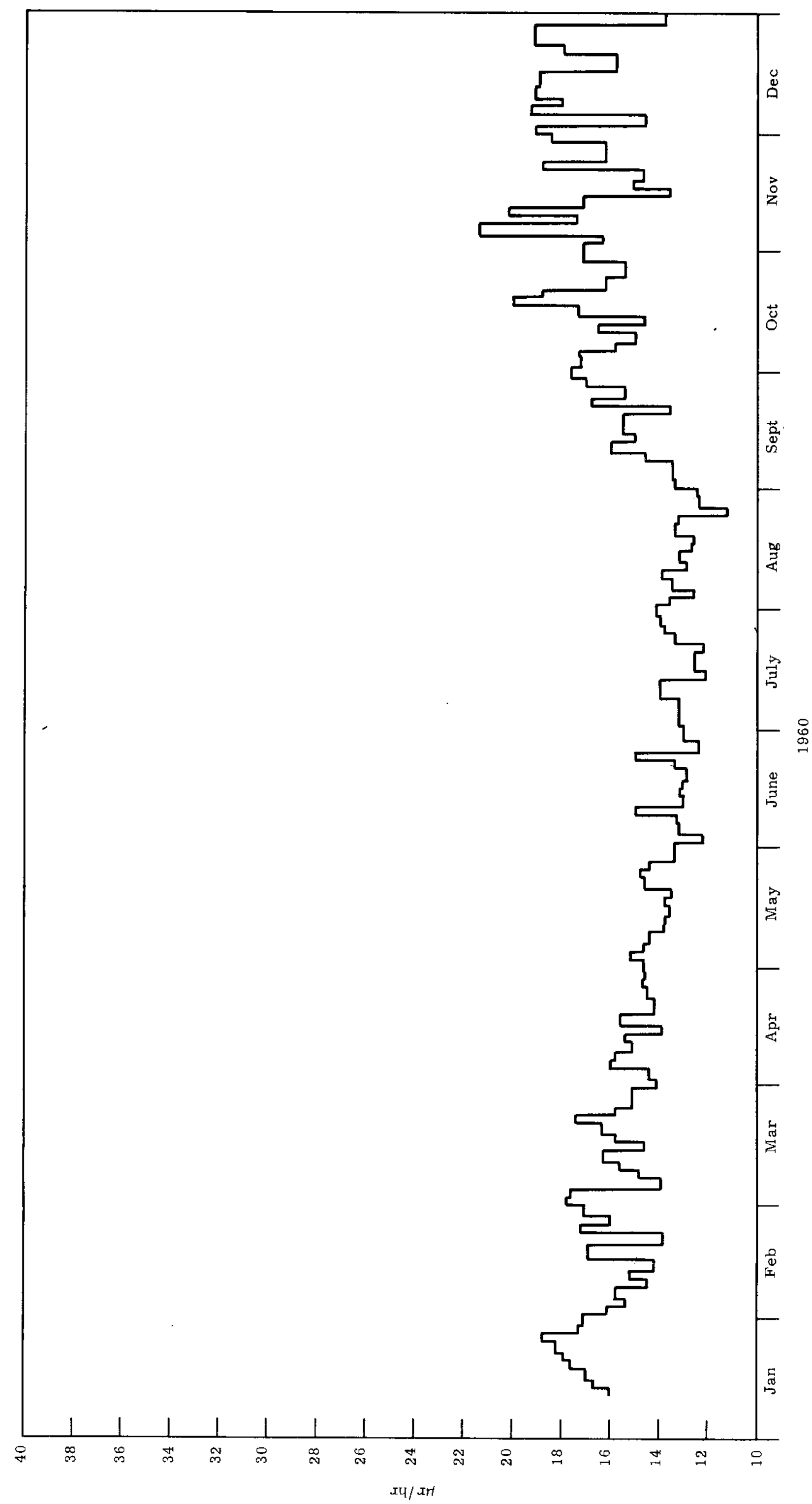

FIGURE 16

Background Dose Rate as Measured at Hanford External Dose Test Location (See Figure 2) from rain or snow rarely, if ever, reaches ground water but is absorbed by plants or evaporated by capillary action. Hence, there is no mechanism available for transporting the contaminants to the water table.

The liquid wastes are disposed of by various means depending on the radioactive contents. "High level wastes", normally containing activity of 100 $\mu c/cc$ or more, are neutralized and stored in concrete tanks lined with mild steel. "Intermediate level wastes", containing activity of approximately 10^{-5} $\mu c/cc$ to 100 $\mu c/cc$, are sent to cribs which are open-work boxes buried in the ground from which liquid waste can percolate into the soil. "Low level wastes", usually containing less than 10^{-5} $\mu c/cc$, are sent to surface ponds. The areas selected for liquid waste disposal have soil with good capacity for storage for depths of 150 to 350 feet above ground water.

The prevention of significant quantities of radiologically important radionuclides from reaching ground water and ultimately the Columbia River is an important objective in local waste disposal practice. For this reason wells have been drilled in and around crib and tank storage areas so that leaks can be detected and the radionuclide content of the ground water determined. The radionuclides present in ground water have historically been associated with liquid waste sent to cribs. Figure 17 shows the probable extent and concentration of radioactive materials in the ground water.[8]

The total quantity of radioactive materials sent to ground (storage tank contents excluded) since plant start-up is estimated as 2.5×10^6 curies. Because of radioactive decay, the current total in the ground is estimated as 2.7×10^5 curies. In order of abundance the bulk of this material is Cs^{137}, Sr^{90} and Ru^{106}. Only minor amounts of other radionuclides are present.

IV. AGGREGATE EXPOSURE FROM ENVIRONMENTAL SOURCE

Because of uncertainties in multiple sources, paths of intake, individual diets, periods of occupancy and so forth, the radiation exposure to individuals in the neighborhood of the Hanford facility cannot be stated precisely. However, useful exposure estimates may be made assuming different exposure parameters. The following estimates of aggregate exposure do not include natural background.

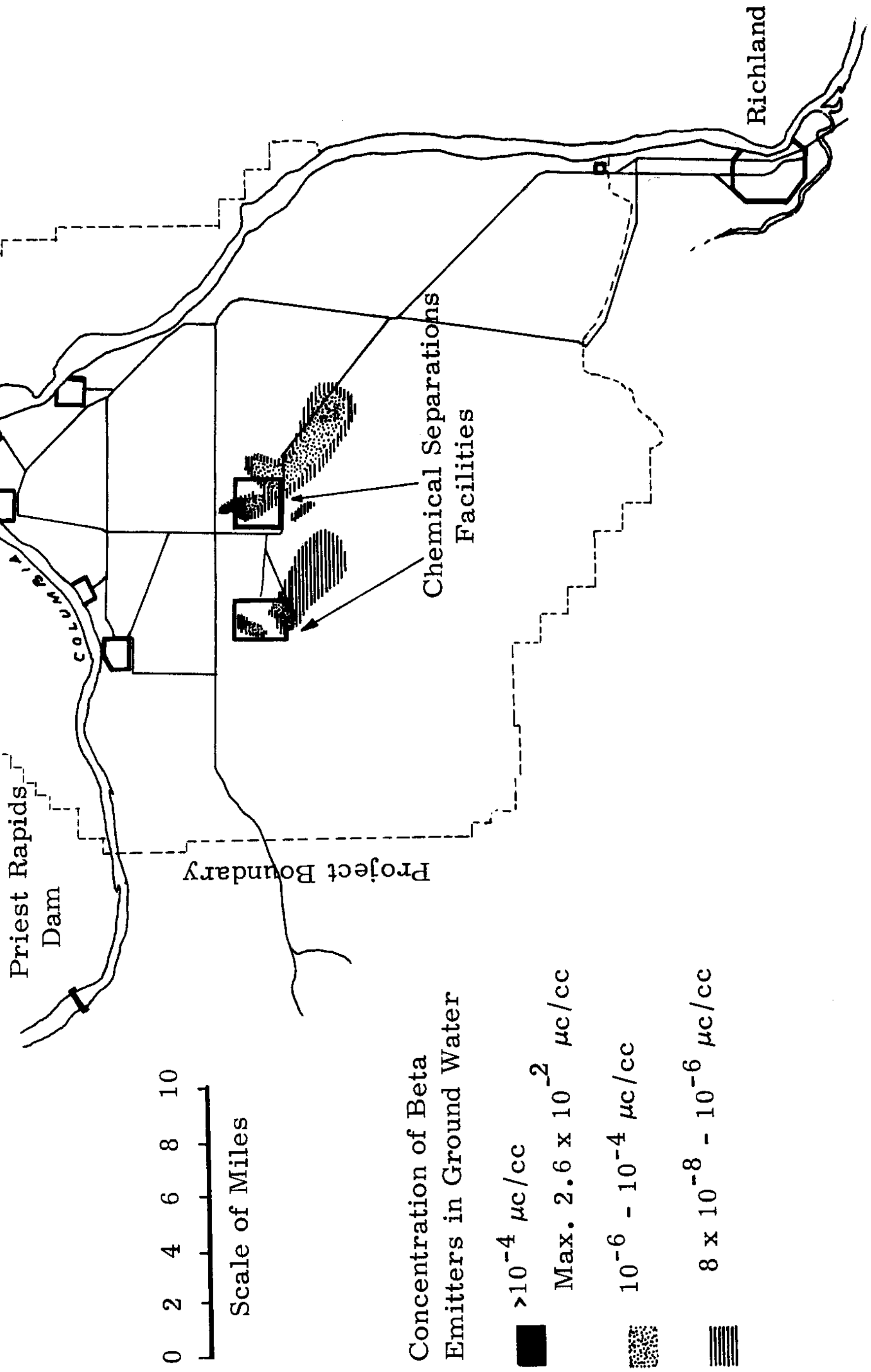

FIGURE 17

Probable Extent of Beta Emitters in Ground Water

The composite exposure for a hypothetical individual whose habits include consumption of local fish at rate of 10 pounds per year, consumption of products from farms irrigated with Columbia River water, consumption of water from the Pasco sanitary system and swimming and boating on the river is estimated at 200 mrems to the GI-tract, 80 mrems to the total body and 40 per cent of the maximum permissible rate of intake for bone.

The residents of Pasco of average dietary habits who drank water from the municipal water system and consumed milk and other foods obtained from local stores would likely have received exposure on the order of 80 mrems to the GI-tract, 10 mrems to the total body and 5 per cent of the maximum permissible rate of intake for bone.

The residents of Richland and other communities who made no use of the Columbia River or products derived therefrom, would have likely received an exposure during 1960 of about 5 mrems to the GI-tract, and total body and 3 per cent of the maximum permissible rate of intake for bone. The primary source of exposure for these individuals was from world wide fallout.

These exposure estimates may be compared with recommendations of the NCRP for continuous exposure of individuals in the neighborhood of controlled areas. These recommendations in the form of maximum permissible limits are 1500 mrems per year to the GI tract, 500 mrems per year to the total body and 100 per cent of the maximum permissible rate of intake in the case of bone seekers.

V. ACKNOWLEDGEMENTS

The cooperation of many General Electric Company personnel who prepared and provided data, and reviewed this document is gratefully acknowledged. All routine analyses were performed by the Radiological Chemical Analysis Operation, F. E. Holt, Supervisor. Specific analyses performed by research groups and which are related to environmental measurements have been referenced in the bibliography.

The cooperation and provision of information by the United States Geological Survey Records Center, Portland, Oregon; the Pasco, Washington, City Water Department and the several state and federal agencies who operated air filter sample stations contributed substantially to the report.

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APPENDIX A
TABLE 1

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN SANITARY WATER
AT PASCO, WASHINGTON - 1960

Units of 10^{-9} $\mu c/cc$ of Water

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	Sr^{89} $+Sr^{90}$	Sr^{90}	Np^{239}
1-5	80	190	170	7,900	260	140	Lost	670	11	0.67	2,900
1-12	92	76	160	8,200	150	140	Lost	540	8.7	0.64	2,300
1-19	66	23	160	7,000	120	100	< 18	510	8.9	0.39	2,000
1-26	63	150	140	2,900	93	97	9.4	300	5.8	0.43	1,100
2-2	100	280	160	6,000	160	160	< 16	570	6.9	0.56	2,100
2-9	43	250	110	5,000	67	190	< 26	180	6.7	0.53	1,200
2-16	71	260	100	4,600	150	220	< 23	280	6.2	< 0.28	1,600
2-23	95	82	160	7,400	75	170	< 21	250	8.5	< 0.51	1,600
3-1	160	410	120	6,300	240	310	< 30	780	11	< 0.28	2,400
3-8	270	350	200	5,300	270	360	< 16	660	6.5	< 0.36	2,400
3-15	140	300	150	6,600	190	240	< 28	460	7.6	0.53	2,100
3-22	280	1,000	23	2,000	710	310	28	990	10	< 0.39	1,700
3-29	77	1,300	10	5,800	370	190	< 38	170	7.6	< 0.42	2,700
4-5	Lost	1,200	11	3,500	560	220	< 18	120	5.0	< 0.37	2,200
4-12	44	700	10	2,000	320	120	< 22	120	2.9	< 0.33	1,200
4-19	41	690	9.1	3,300	400	150	31	270	2.5	< 0.33	1,800
4-26	54	750	17	2,600	420	130	26	280	2.4	0.29	1,400
5-3	110	930	33	3,500	570	160	41	316	4.4	< 0.29	1,700
5-10	200	1,400	52	4,700	1,300	150	33	500	6.9	< 0.34	2,000
5-17	32	610	3.9	2,200	240	120	< 31	56	2.9	< 0.46	870
5-24	74	890	11	2,300	530	67	< 31	180	2.3	< 0.30	870
6-1	99	820	65	1,700	600	84	< 43	230	1.0	< 0.37	660
6-7	46	690	8.3	1,600	310	59	< 50	200	3.0	0.39	700
6-14	180	910	6.2	1,700	290	39	< 18	84	2.0	< 0.32	690

APPENDIX A
TABLE 1 (CONTINUED)

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	Sr^{89} $+Sr^{90}$	Sr^{90}	Np^{239}
6-21	71	710	12	1,400	430	36	< 37	Lost	2.2	< 0.39	660
6-28	74	840	5.3	2,000	640	25	< 21	160	1.8	< 0.26	550
7-6	47	600	7.6	1,200	370	86	< 16	110	1.8	< 0.36	540
7-12	50	750	4.0	1,200	240	47	< 19	48	1.6	< 0.60	530
7-19	72	600	11	1,400	350	14	< 26	48	2.3	< 0.43	660
7-26	170	1,000	27	2,300	720	37	< 24	370	2.2	< 0.62	940
8-2	96	640	30	3,400	380	48	< 51	410	3.6	< 0.42	1,500
8-9	130	670	19	2,100	540	51	< 28	400	1.9	< 0.29	970
8-16	87	990	19	3,400	470	40	< 25	280	5.4	< 0.44	1,200
8-23	67	650	11	4,100	230	43	Lost	57	4.2	0.37	1,300
8-30	94	1,000	20	5,600	420	75	14	250	3.6	< 0.25	2,100
9-7	200	1,100	58	7,300	560	73	15	680	8.4	0.50	2,800
9-13	130	820	38	5,700	370	72	< 16	500	3.9	0.51	1,900
9-20	97	1,600	34	7,500	530	77	< 36	1,800	3.8	0.38	3,000
9-27	50	760	34	5,500	230	48	< 25	190	6.9	0.44	2,200
10-4	78	1,100	56	7,800	430	53	< 18	570	6.9	0.38	2,900
10-11	69	540	41	6,600	100	74	< 17	310	5.7	0.32	1,900
10-18	130	620	40	7,400	220	120	< 11	450	5.5	0.28	2,600
10-25	76	470	60	5,900	130	81	< 13	450	7.3	< 0.74	2,500
11-1	51	470	32	5,600	112	89	< 15	260	5.2	0.46	2,300
11-8	28	470	40	7,700	140	93	< 25	370	5.7	0.49	3,000
11-15	65	290	36	6,500	130	140	< 18	340	9.0	0.50	2,100
11-22	110	310	75	6,900	170	150	< 24	370	6.4	< 0.58	2,500
11-29	120	1,200	73	9,500	500	49	< 22	630	5.6	< 0.56	4,000
12-6	120	910	62	7,600	360	74	< 16	660	8.2	0.57	4,000
12-13	1,300*	780	120	9,100	330	85	< 31	870	11	0.39	3,900

* Questionable analytical result - disregard.

APPENDIX A
TABLE 2

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN SANITARY WATER
AT KENNEWICK, WASHINGTON - 1960

Units of 10^{-9} μc/cc of Water

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	$Sr^{89}+Sr^{90}$	Sr^{90}	Np^{239}
2-2	16	90	11	2,400	110	13	< 19	130	0.47	< 0.27	180
2-9	45	69	29	3,000	220	46	Lost	120	1.8	< 0.30	480
2-16	60	130	35	2,500	94	23	< 15	150	1.4	< 0.29	290
2-23	18	59	11	2,700	31	16	Lost	< 61	0.79	< 0.54	120
3-1	25	120	14	3,200	100	27	< 22	< 73	1.3	< 0.29	290
3-8	31	30	15	2,900	100	26	< 18	< 76	0.69	< 0.32	260
3-15	28	75	13	3,400	68	26	< 26	< 78	< 0.63	< 0.40	220
3-22	32	140	16	3,800	170	40	< 22	73	0.87	< 0.41	510
3-29	44	120	15	3,100	100	< 25	< 14	54	< 0.57	< 0.34	190
4-5	Lost	250	27	2,300	270	39	< 21	120	0.87	< 0.30	330
4-12	25	69	7.7	1,400	79	17	< 25	41	< 0.63	< 0.31	120
4-19	40	100	11	1,500	110	11	< 24	61	0.81	< 0.30	120
4-26	44	110	8.4	1,600	80	20	< 46	19	< 0.50	< 0.31	160
5-3	29	110	10	1,700	120	13	< 16	42	< 0.47	< 0.31	120
5-17	20	180	5.7	1,500	78	8.0	< 32	41	< 0.92	< 0.35	63
5-24	20	66	5.3	1,300	90	3.4	< 34	< 88	0.57	< 0.35	61
6-1	34	180	9.0	1,400	230	19	< 26	71	3.0	< 0.37	120
6-7	34	180	10	1,200	230	14	< 34	87	0.97	< 0.33	160
6-14	56	260	11	1,400	210	13	< 30	69	< 0.84	< 0.33	170

APPENDIX A
TABLE 2 (CONTINUED)

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	Sr^{89} $+Sr^{90}$	Sr^{90}	Np^{239}
6-21	11	35	< 4.8	850	48	9.8	< 36	42	< 0.43	< 0.28	45
6-28	34	220	< 3.2	1,600	250	11	< 18	69	< 0.42	< 0.27	140
7-6	38	140	5.7	1,400	210	3.2	< 15	36	0.77	< 0.34	130
7-12	73	260	9.4	1,400	280	8.2	< 20	62	< 0.41	< 0.53	170
7-19	26	160	6.1	1,200	190	35	< 22	50	0.97	< 0.37	170
7-26	36	290	< 5.8	1,700	290	2.5	< 31	84	< 0.98	< 0.58	190
8-2	27	140	7.0	1,900	170	< 1.7	< 18	83	1.2	< 0.32	150
8-9	28	150	8.2	1,700	150	11	< 39	83	0.95	< 0.41	230
8-16	6.4	42	< 3.2	1,400	51	17	< 17	20	< 0.50	< 0.28	86
8-23	4.8	210	< 3.2	2,200	46	< 17	Lost	24	< 0.43	< 0.26	82
8-30	8.3	90	< 3.1	3,000	78	< 10	< 17	47	< 0.46	< 0.31	190
9-7	6.1	93	< 3.2	2,900	49	< 11	< 13	33	< 1.1	0.23	130
9-13	9.6	49	< 3.1	3,000	44	< 19	< 16	21	< 0.75	0.51	86
9-20	6.0	50	< 3.2	3,200	33	12	Lost	< 37	< 0.41	< 0.26	110
9-27	5.4	38	< 3.1	3,300	38	< 12	< 19	< 46	< 0.64	< 0.42	60
10-4	6.4	44	< 5.9	3,300	42	< 11	< 19	< 40	< 0.55	< 0.36	90
10-11	5.8	62	< 4.1	3,200	52	< 11	< 16	< 37	< 0.62	< 0.41	150
10-18	8.4	46	4.9	3,400	34	< 12	< 12	< 60	1.3	< 0.37	150
10-25	11	52	5.8	3,100	31	< 12	< 12	< 40	< 0.50	< 1.1	120
11-1	9.7	78	< 5.7	3,100	62	< 11	< 17	< 76	< 0.51	< 0.33	160
11-8	37	120	15	3,500	120	< 12	< 19	120	0.57	< 0.38	350
11-15	7.3	56	< 5.8	3,200	39	< 12	< 18	100	< 0.67	< 0.35	130
11-22	20	80	24	4,000	140	< 11	< 17	110	< 0.93	< 0.33	330
11-29	8.4	77	8.8	4,400	140	< 12	< 20	78	< 0.68	< 2.0	210
12-6	10	73	12	3,700	67	< 12	< 15	120	< 0.99	< 0.35	200
12-13	990*	52	14	4,100	50	< 10	< 18	66	< 0.82	< 0.29	210

* Questionable analytical result - disregard.

APPENDIX A
TABLE 3

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER
AT PASCO, WASHINGTON - 1960

Units of 10^{-9} μc/cc of Water

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	$Sr^{89}+Sr^{90}$	Sr^{90}	Np^{239}
1-5	480	390	280	8,500	1,500	310	Lost	1,500	11	0.48	4,400
1-12	740	840	240	8,400	1,800	370	Lost	2,200	10	0.63	4,700
1-19	460	670	300	9,000	1,900	340	88	1,600	8.2	0.51	11,000
1-26	320	720	170	3,700	1,000	300	55	1,000	9.3	0.53	2,200
2-2	530	1,500	220	4,500	2,200	370	130	1,600	4.9	< 0.38	2,800
2-9	320	760	210	5,900	840	330	< 18	950	11	0.66	2,800
2-16	540	1,500	300	6,800	1,700	410	94	1,400	8.8	< 0.33	3,700
2-23	790	1,100	350	8,400	1,200	540	< 13	1,500	7.2	0.45	3,800
3-1	890	1,400	280	7,900	1,500	440	140	1,300	17	< 0.41	4,400
3-8	840	1,200	250	6,600	1,200	450	67	1,200	7.9	< 0.54	3,900
3-15	1,200	1,500	300	7,500	2,200	530	150	1,700	10	0.76	4,300
3-17	620	1,500	350	8,900	1,800	540	110	2,000	14	< 0.55	4,900
3-22	1,000	1,600	350	8,100	2,000	490	150	1,800	12	0.72	4,300
3-29	920	2,100	330	6,400	2,100	420	130	1,400	7.8	< 0.66	3,600
4-5	Lost	1,900	200	3,700	2,600	360	150	1,400	4.3	< 0.34	3,600
4-12	720	2,000	120	2,800	2,600	230	240	1,200	4.0	0.84	2,000
4-19	690	2,000	170	3,400	3,600	290	400	1,800	3.2	< 0.41	1,800
4-26	790	1,500	160	3,100	3,000	270	Lost	1,200	2.3	< 0.35	2,000
5-3	980	1,500	200	4,800	2,900	320	330	1,500	5.2	0.51	2,300
5-10	950	2,300	220	5,500	3,400	340	240	1,800	6.5	< 0.38	2,600
5-17	710	1,600	110	2,900	2,700	210	NA*	1,100	3.2	< 0.44	1,400
5-24	550	1,600	100	2,900	2,700	270	270	880	3.0	< 0.42	1,200
6-1	390	1,300	21	2,000	2,000	150	140	1,000	2.6	< 0.34	850
6-7	690	1,200	66	1,800	1,700	130	120	590	3.4	< 0.46	910
6-14	490	1,400	59	2,100	2,300	140	110	690	2.9	< 0.33	980

*No Analysis

APPENDIX A
TABLE 3 (CONTINUED)

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	Sr^{89} $+Sr^{90}$	Sr^{90}	Np^{239}
6-21	440	1,000	54	1,700	1,800	120	120	320	2.8	< 0.34	880
6-28	370	1,100	51	1,800	1,900	110	< 68	490	1.8	< 0.26	980
7-6	330	750	35	1,300	1,200	81	110	390	1.8	< 0.32	670
7-12	460	980	41	1,200	1,400	160	86	440	1.5	< 0.51	740
7-19	280	700	33	1,600	1,200	82	56	410	4.8	< 0.41	770
7-26	450	1,400	48	2,100	1,800	110	66	630	1.9	< 0.53	1,300
8-2	450	1,700	74	4,000	2,400	140	87	1,200	4.3	< 0.35	1,700
8-9	320	870	56	2,300	1,500	150	80	670	2.5	< 0.42	1,200
8-16	390	1,900	78	2,900	2,400	180	47	1,800	4.3	< 0.34	2,100
8-23	340	720	83	4,300	2,300	180	Lost	1,200	4.7	0.48	2,400
8-30	370	1,600	95	6,200	2,100	210	45	1,300	4.2	< 0.28	2,900
9-7	540	2,500	120	8,000	2,500	410	53	1,800	8.5	0.79	4,300
9-13	370	2,000	100	5,700	1,800	270	28	1,400	4.5	< 0.32	3,100
9-20	350	2,400	120	7,600	2,300	290	31	1,900	4.4	0.58	4,100
9-27	420	1,900	180	6,800	1,800	390	40	1,400	7.8	< 0.49	3,400
10-4	380	2,200	230	7,600	2,400	300	32	2,200	6.8	< 0.39	4,400
10-11	540	3,000	380	10,000	2,500	330	26	2,800	7.9	< 0.34	6,100
10-18	380	1,700	260	6,600	1,700	260	16	2,100	6.9	0.62	4,000
10-25	440	1,900	330	7,900	1,900	290	20	2,800	8.4	0.63	5,500
11-1	470	2,100	270	6,200	2,200	290	46	2,100	5.7	0.55	4,600
11-8	570	1,300	360	9,800	1,400	380	18	2,100	6.1	< 0.34	5,500
11-15	390	1,700	290	7,200	1,800	300	23	2,100	6.8	0.57	4,100
11-22	360	940	360	6,900	1,200	320	14	1,600	3.3	< 0.49	4,500
11-29	530	2,400	570	11,000	3,000	480	57	3,300	6.6	< 0.97	7,400
12-6	620	1,800	570	9,000	2,000	460	47	2,800	14	0.55	6,500
12-13	2,700*	1,000	580	9,300	1,000	340	40	2,100	12	0.42	5,300

* Questionable analytical result - disregard.

APPENDIX A
TABLE 4

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER AT VANCOUVER, WASHINGTON - 1960

Units of 10^{-9} μc/cc of Water

Date	P^{32}	Cr^{51}	Zn^{65}	Np^{239}
1-12	33	2,300	64	66
1-26	74	4,100	150	160
2-9	39	2,400	83	110
2-23	54	2,200	150	96
3-15	85	2,800	130	81
3-22	71	2,700	110	67
4-5	72	2,100	100	210
4-19	51	1,100	91	280
5-3	33	1,300	66	130
5-17	21	1,900	130	250
6-7	26	930	61	120
6-21	33	1,300	140	220
7-12	21	1,300	65	170
7-26	16	1,400	42	140
8-9	23	2,500	55	140
8-23	17	1,400	14	36
9-13	16	3,100	57	47
9-27	11	2,600	23	25
10-12	31	3,100	13	83
10-25	31	1,500	< 12	23
11-8	48	2,700	27	480
12-6	86	1,000	61	40

APPENDIX A
TABLE 5

BETA EMITTERS IN COLUMBIA RIVER WATER - 1960
Units of d/s per cc of Water

Location	January	February	March	April	May	June	July	August	September	October	November	December
Wills Ranch (Upstream from Project)	-*	NA**	NA	-	NA	NA	-	NA	NA	NA	-	NA
Hanford (Old Townsite)	2.3	2.3	2.9	1.7	1.8	0.97	0.48	1.0	1.7	2.2	2.0	2.6
Richland, Washington	1.3	0.83	1.1	0.59	0.81	0.53	0.28	0.49	0.74	1.2	1.2	1.4
Sacajawea Park	0.44	0.43	0.44	0.27	0.32	0.20	0.20	0.24	0.35	0.52	0.53	0.73
McNary (Below Dam)	0.062	0.057	0.048	0.067	0.065	0.053	0.030	0.045	0.037	0.046	0.048	0.073
Paterson Ferry (Oregon Side)	0.043	0.035	0.042	0.045	0.062	0.034	0.043	0.055	0.039	0.025	0.042	NA
Hood River, Oregon	0.0018	0.022	0.016	0.022	0.020	0.013	0.024	0.017	0.0092	0.00030	0.017	NA
Vancouver, Washington	0.014	0.012	0.013	0.018	0.013	0.0093	0.12	0.011	0.0098	0.011	0.012	NA

* Concentrations of gross beta radioactivity below the reporting limit of 0.0005 d/s per cc are indicated by a (-).

** No Analysis.

APPENDIX A
TABLE 6

CONCENTRATION OF P^{32} IN SELECTED ORGANISMS - 1960

Units of 10^{-3} $\mu c/g$ (wet)

Date	Organism	Location	Number of Samples	Average	Maximum
1-18	Whitefish Flesh	River, Ringold Area	3	0.32	0.7
1-19	Whitefish Flesh	River, Priest Rapids Area	1	0.0068	-
1-20	Whitefish Flesh	River, near Reactors	1	0.21	-
1-27	Diving Ducks	River, near Reactors	7	2.1	3.1
	River Ducks	River, near Reactors	9	0.2	1.5
3-10	Minnows, (Whole Fish)	River, near Reactors	7	1.0	1.4
	Salmon, Juvenile, (Entire Fish)	River, near Reactors	1	0.026	-
4-5	Minnows, (Whole Fish)	River, near Reactors	8	1.5	2.2
	Salmon, Juvenile, (Entire Fish)	River, near Reactors	8	3.4	5.2
5-16	Salmon, Juvenile, (Entire Fish)	River, near Reactors	3	1.8	2.6
	Minnows, (Whole Fish)	River, near Reactors	12	2.4	2.7
6-16	Minnows, (Whole Fish)	River, near Reactors	10	5.8	6.1
7-6	Minnows, (Whole Fish)	River, near Reactors	10	9.4	10
	Shiners	River, near Reactors	10	9.4	10
8-11	Shiners	River, near Reactors	10	21	24
9-12	Shiners	River, near Reactors	10	47	76
10-10	Whitefish Flesh	River, Ringold Area	10	2.9	5.6
10-12	LM Bass, Flesh	River, Hanford Area	1	1.6	-
	Squawfish Flesh	River, Hanford Area	2	0.96	1.1
10-17	Whitefish Flesh	River, Hanford Area	8	2.2	2.9
10-18	SM Bass Flesh	River, Hanford Area	1	0.86	-
	Chiselmouth, Flesh	River, Hanford Area	4	5.2	5.7
	Shiner, Entire Minnow	River, Hanford Area	3	31	32
	Squawfish, Flesh	River, Hanford Area	1	2.2	-
	CS Sucker, Flesh	River, Hanford Area	5	3.8	4.9
10-20	Whitefish, Flesh	River, Priest Rapids Area	11	0.011	0.034

APPENDIX A
TABLE 6 (CONTINUED)

Date	Organism	Location	Number of Samples	Average	Maximum
10-24	Mallard, Flesh	Separations Plant Swamp	5	0.057	0.12
	Green Winged Teal	" " "	1	0.032	-
	American Shoveler	" " "	3	0.20	0.32
	Northern American Coot	" " "	1	0.06	-
10-26	Carp, Flesh	River, McNary Dam Area	4	0.098	0.14
	Chiselmouth Flesh	" " " "	5	1.7	2.7
	Chub, Flesh	" " " "	3	0.34	0.46
	Shiner, Entire Minnow	" " " "	1	3.2	-
	Squawfish, Flesh	" " " "	5	0.18	0.27
	CS Sucker, Flesh	" " " "	5	0.28	0.35
	FS Sucker, Flesh	" " " "	5	1.1	1.4
	Whitefish, Flesh	" " " "	1	0.25	-
	Black Catfish, Flesh	" " " "	2	0.15	0.18
	Channel Catfish, Flesh	" " " "	3	0.21	0.44
	Punkinseed, Flesh	" " " "	1	0.22	-
10-28	SM Bass, Flesh	River, Hanford Area	2	1.4	1.7
	SM Bass, Entire Minnow	" " "	1	3.8	-
	Carp, Flesh	" " "	2	0.39	0.60
	Yellow Perch, Flesh	" " "	2	1.6	1.7
	Shiner, Entire Minnow	" " "	2	24	24
	Squawfish, Entire Minnow	" " "	2	15	16
	Squawfish, Flesh	" " "	4	0.31	0.44
11-1	American Common Goldeneye	River, Hanford & Upstream	2	0.014	0.020
	Mallard, Flesh	" " "	6	1.4	5.0
	Barrow Goldeneye, Flesh	" " "	2	0.46	0.77
	Bufflehead	" " "	1	0.006	-
	American Common Merganser	" " "	5	3.9	6.3
	Surf Scoter	" " "	1	0.029	-
11-2	Mallard, Flesh	River, Burbank Area	1	0.011	-
11-3	Mallard, Flesh	River, Hanford & Downstream	6	0.23	0.91
	American Common Merganser	" " "	1	2.6	-
	Northern American Coot	" " "	6	0.039	0.083

APPENDIX A
TABLE 6 (CONTINUED)

Date	Organism	Location	Number of Samples	Average	Maximum
11-3	Chiselmouth Flesh	River, Burbank Area	5	1.9	2.9
	CS Sucker Flesh	River, Burbank Area	5	0.25	0.31
	FS Sucker Flesh	River, Burbank Area	5	1.2	3.8
11-9	Salmon Flesh	River, Richland Area	2	1.1	2.1
	Whitefish Flesh	River, Richland Area	12	1.2	3.8
11-10	Carp Flesh	River, Richland Area	1	1.3	-
	Chiselmouth Flesh	River, Richland Area	5	2.8	3.3
	Chub, Entire Minnow	River, Richland Area	3	8.3	8.5
	Shiner, Entire Minnow	River, Richland Area	2	12	12
	Squawfish Flesh	River, Richland Area	2	0.10	0.13
	Squawfish, Entire Minnow	River, Richland Area	2	7.9	7.9
	Sturgeon Flesh	River, Richland Area	1	0.019	-
	CS Sucker Flesh	River, Richland Area	2	0.27	0.39
	FS Sucker Flesh	River, Richland Area	5	4.8	4.9
11-11	Chub, Entire Minnow	River, Hanford Area	3	11	12
	Shiner, Entire Minnow	River, Hanford Area	5	18	19
	Squawfish, Entire Minnow	River, Hanford Area	2	1.3	1.3
	Whitefish Flesh	River, Hanford Area	13	1.1	2.2
11-14	Shiner, Entire Minnow	River, Ringold Area	3	13	13
	Whitefish Flesh	River, Ringold Area	12	3.0	9.5
11-15	Carp Flesh	River, Ringold Area	1	1.5	-
	Chiselmouth Flesh	River, Ringold Area	1	3.4	-
	Squawfish, Flesh	River, Ringold Area	5	0.27	0.53
	CS Sucker Flesh	River, Ringold Area	5	0.87	1.5
11-16	Yellow Perch Flesh	River, Ringold Area	3	0.47	0.65
	FS Sucker, Flesh	River, Ringold Area	4	3.1	3.8
11-21	Whitefish Flesh	River, Priest Rapids Area	7	0.45	1.7
11-22	Chiselmouth Flesh	River, Priest Rapids Area	5	0.77	1.1
	Chub Flesh	River, Priest Rapids Area	5	0.28	0.81
	Shiner Flesh	River, Priest Rapids Area	1	0.054	-
	Squawfish Flesh	River, Priest Rapids Area	6	0.015	0.034
	Sturgeon Flesh	River, Priest Rapids Area	1	0.013	-

APPENDIX A
TABLE 6 (CONTINUED)

Date	Organism	Location	Number of Samples	Average	Maximum
11-22	CS Sucker Flesh	River, Priest Rapids Area	4	0.16	0.36
	FS Sucker Flesh	River, Priest Rapids Area	2	0.18	0.33
	Whitefish Flesh	River, Priest Rapids Area	6	0.14	0.34
11-29	American Common Goldeneye	River, Hanford & Upstream	1	0.01	-
	Barrow Goldeneye	River, Hanford & Upstream	4	3.7	5.5
	American Common Merganser	River, Hanford & Upstream	1	0.47	-
11-30	Whitefish Flesh	River, Hanford Area	10	0.77	1.3
	Mallard Flesh	River, Hanford & Upstream	2	0.24	0.44
	American Common Goldeneye	River, Hanford & Upstream	1	0.84	-
12-2	Shiner, Entire Minnow	River, Hanford Area	6	10	12
	Squawfish, Entire Minnow	River, Hanford Area	3	5.8	6.7
	Mallard Flesh	River, Hanford & Downstream	6	0.18	0.53
	Green Winged Teal	River, Hanford & Downstream	2	4.6	7.8
	Barrow Goldeneye	River, Hanford & Downstream	2	1.7	2.6
12-8	Shiner, Entire Minnow	River, Ringold Area	3	6.4	6.5
	Squawfish, Entire Minnow	River, Ringold Area	1	4.0	-
	Squawfish Flesh	River, Ringold Area	1	0.15	-
	Whitefish Flesh	River, Ringold Area	6	0.95	3.2
	Northern American Coot	River, Hanford & Downstream	2	0.30	0.30
12-9	CS Sucker Flesh	River, Ringold Area	2	0.87	1.4
	American Common Goldeneye	River, Hanford & Downstream	1	3.2	-
12-12	Mallard Flesh	Separations Plant Swamp	2	0.26	0.29
12-13	Whitefish Flesh	River, McNary Dam Area	2	0.90	1.1
12-14	Shiner, Entire Minnow	River, Richland Area	2	4.9	4.9
	Squawfish, Entire Minnow	River, Richland Area	3	3.7	3.8
	CS Sucker Flesh	River, Richland Area	2	0.42	0.43
12-15	FS Sucker Flesh	River, Richland Area	5	3.2	3.8
	Whitefish Flesh	River, Richland Area	8	0.59	1.5
	Lesser Canada Goose	River, Hanford & Downstream	1	0.0095	-
	Mallard Flesh	River, Hanford & Downstream	1	0.22	-
	Mallard Flesh	Separations Plant Swamp	2	0.17	0.25
	American Pintail	Separations Plant Swamp	1	0.34	-

APPENDIX A
TABLE 6 (CONTINUED)

Date	Organism	Location	Number of Samples	Average	Maximum
12-15	American Common Goldeneye	Separations Plant Swamp	1	0.046	-
	Northern Ruddy Duck	Separations Plant Swamp	2	0.039	0.057
12-19	Sturgeon Flesh	River, Priest Rapids Area	2	0.010	0.011
	Whitefish Flesh	River, Priest Rapids Area	7	0.14	0.44
12-27	Whitefish Flesh	River, McNary Dam Area	2	0.079	0.090
12-28	Chiselmouth Flesh	River, McNary Dam Area	5	0.31	0.69
	CS Sucker Flesh	River, McNary Dam Area	3	0.14	0.18

APPENDIX A
TABLE 7

ESTIMATED RATE OF TRANSPORT FOR SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER PASSING PASCO, WASHINGTON - 1960

Units of curies/day

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	$Sr^{89}+Sr^{90}$	Sr^{90}	Np^{239}
1-5	88	72	51	1,600	280	57	NA*	280	2.1	0.088	810
1-12	130	150	43	1,500	320	67	NA	400	1.8	0.11	850
1-19	110	160	74	2,200	470	83	22	390	2.0	0.13	2,700
1-26	70	160	37	810	220	66	12	220	2.0	0.12	480
2-2	120	330	48	990	480	81	29	350	< 1.0	< 0.084	620
2-9	59	140	39	1,100	150	61	< 3.3	170	1.9	0.12	510
2-16	94	260	52	1,200	300	71	16	240	< 1.6	< 0.058	640
2-23	130	180	58	1,400	200	89	< 2.1	250	1.2	0.074	630
3-1	140	220	43	1,200	230	68	22	200	< 2.7	< 0.064	680
3-8	130	190	40	1,000	190	71	11	190	< 1.3	< 0.085	620
3-15	200	250	51	1,300	370	89	25	290	1.7	0.13	720
3-17	110	260	62	1,600	320	95	19	350	< 2.4	< 0.097	860
3-22	180	280	62	1,400	360	87	27	320	2.1	0.13	760
3-29	260	590	92	1,800	590	120	36	390	< 2.2	< 0.18	1,000
4-5	Lost	700	74	1,400	960	130	55	520	< 1.6	< 0.13	1,300
4-12	350	960	58	1,300	1,200	110	120	580	1.9	0.40	960
4-19	300	880	75	1,500	1,600	130	180	800	< 1.4	< 0.18	800
4-26	310	590	63	1,200	1,200	110	Lost	470	< 0.93	< 0.14	790
5-3	320	490	65	1,600	940	100	110	490	1.7	0.17	750
5-10	290	710	68	1,700	1,000	100	74	550	< 2.0	< 0.12	800
5-17	410	920	63	1,700	1,500	120	NA	630	< 1.8	< 0.25	800
5-24	340	1,000	62	1,800	1,700	170	170	550	< 1.9	< 0.26	750
6-1	230	770	12	1,200	1,200	88	82	590	< 1.6	< 0.20	500
6-7	480	830	46	1,300	1,200	90	83	410	< 2.3	< 0.32	630
6-14	350	1,000	43	1,500	1,700	100	79	500	< 2.1	< 0.24	710

*No Analysis

APPENDIX A
TABLE 7 (CONTINUED)

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	Sr^{89} $+Sr^{90}$	Sr^{90}	Np^{239}
6-21	330	740	40	1,300	1,300	89	89	240	2.1	< 2.5	650
6-28	230	680	31	1,100	1,200	68	< 42	300	1.1	< 0.16	600
7-6	250	570	27	990	920	62	84	300	1.4	< 0.24	510
7-12	310	660	28	810	950	110	58	300	1.0	< 0.34	500
7-19	170	420	20	970	730	50	34	250	2.9	< 0.25	470
7-26	220	700	24	1,000	900	55	33	310	0.95	< 0.26	650
8-2	170	660	29	1,600	930	54	34	470	1.7	< 0.14	660
8-9	110	310	20	820	540	54	29	240	0.89	< 0.15	430
8-16	120	580	24	890	740	55	14	550	1.3	< 0.10	640
8-23	85	180	21	1,100	570	45	Lost	300	1.2	0.12	600
8-30	71	310	18	1,200	410	41	8.7	250	0.81	< 0.054	560
9-7	98	450	22	1,400	450	74	9.6	330	1.5	0.14	780
9-13	70	380	19	1,100	340	51	5.3	270	0.86	< 0.061	590
9-20	60	410	21	1,300	390	50	5.3	320	0.75	0.099	700
9-27	88	400	38	1,400	380	82	8.4	290	1.6	< 0.10	720
10-4	71	410	43	1,400	450	56	6.0	410	1.3	< 0.073	830
10-11	83	460	58	1,500	380	51	4.0	430	1.2	< 0.052	940
10-18	56	250	38	970	250	38	2.4	310	1.0	0.091	590
10-25	74	320	55	1,300	320	49	3.4	470	1.4	0.11	920
11-1	83	370	48	1,100	390	51	8.1	370	1.0	0.097	810
11-8	91	210	57	1,600	220	61	2.9	330	0.97	0.054	880
11-15	67	290	50	1,200	310	52	4.0	360	1.2	0.098	700
11-22	65	170	65	1,200	220	58	2.5	290	0.60	< 0.089	820
11-29	100	460	110	2,100	580	93	11	640	1.3	< 0.19	1,400
12-6	90	260	83	1,300	290	67	6.8	400	2.0	0.080	950
12-13	410	150	88	1,400	150	52	6.1	320	1.8	0.064	800

APPENDIX A
TABLE 8

ESTIMATED RATE OF TRANSPORT FOR SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER PASSING VANCOUVER, WASHINGTON - 1960

Units of curies/day

Date	P^{32}	Cr^{51}	Zn^{65}	Np^{239}
1-12	9.2	640	18	18
1-26	24	1,300	48	51
2-9	15	920	32	42
2-23	15	620	42	27
3-15	24	790	37	23
3-22	23	880	36	22
4-5	43	1,200	59	120
4-19	34	730	60	190
5-3	17	660	34	66
5-17	19	1,700	120	220
6-7	28	1,000	66	130
6-21	33	1,300	140	220
7-12	16	1,000	51	130
7-26	9.5	830	25	83
8-9	9.8	1,100	23	60
8-23	5.3	440	4.4	11
9-13	4.1	800	15	12
9-27	3.2	750	6.7	7.2
10-12	7.3	730	3.1	20
10-25	7.0	340	< 2.7	5.2
11-8	12	660	6.6	117
12-6	20	230	14	9.3

APPENDIX A
TABLE 9

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER AT HANFORD FERRY - 1960

Units of 10^{-9} μc/cc of Water

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	Zn^{69m}	As^{76}	Sr^{89} + Sr^{90}	Sr^{90}	Np^{239}
1-4	3,800	6,400	570	17,000	24,000	650	1,000	8,000	18	0.22	13,000
1-18	3,600	5,800	600	17,000	25,000	680	1,300	8,200	13	0.51	12,000
2-1	3,500	4,100	460	9,700	16,000	580	1,000	6,700	9.8	0.83	6,700
2-15	2,900	11,000	590	13,000	22,000	700	1,600	6,200	16	0.44	7,100
2-29	3,400	7,800	440	12,000	12,000	900	1,000	4,900	32	0.86	8,600
3-14	3,500	5,100	520	14,000	17,000	920	1,300	5,700	27	0.62	9,800
3-28	4,800	14,000	740	15,000	20,000	930	1,300	6,000	13	0.66	9,300
4-11	2,800	5,200	260	5,100	6,300	410	820	3,100	6.5	0.39	5,000
4-25	1,300	6,800	360	7,500	20,000	740	2,500	4,200	4.7	0.28	5,100
5-16	3,600	2,800	220	9,200	11,000	730	1,900	2,500	5.9	0.66	5,800
5-31	2,100	3,600	140	4,500	8,100	260	270	2,300	15	0.46	2,000
6-6	1,500	3,700	130	3,700	6,400	230	450	470	6.4	0.33	2,100
6-20	1,600	2,800	94	3,200	5,000	200	260	1,100	3.2	< 0.31	1,800
6-27	1,800	3,300	94	3,000	5,400	180	340	1,300	2.4	< 0.29	1,700
7-11	1,700	3,200	84	3,100	5,500	240	280	1,000	2.9	< 0.63	1,900
7-25	2,200	4,200	100	3,900	6,600	180	230	1,600	3.7	< 0.66	2,400
8-8	3,300	3,800	130	5,000	10,000	310	360	3,000	5.7	0.94	3,000
8-22	2,700	7,100	220	10,000	14,000	370	420	4,200	7.8	0.48	6,000
9-6	3,300	6,400	330	16,000	20,000	610	400	5,600	11	0.50	10,000
9-26	3,400	12,000	390	15,000	19,000	750	470	6,500	14	0.42	9,500
10-10	3,000	13,000	590	16,000	17,000	810	460	7,700	12	0.50	8,200
10-24	1,100	5,000	390	11,000	6,000	600	96	4,200	18	< 0.97	7,500
11-8	3,900	14,000	800	19,000	21,000	870	410	11,000	11	0.74	16,000
11-21	1,600	7,200	500	9,900	11,000	510	200	5,900	8.1	< 0.23	8,800
12-15	2,500	11,000	850	15,000	16,000	740	450	9,000	17	0.64	13,000

APPENDIX B
TABLE 1

AVERAGE RADIOACTIVE PARTICLE CONCENTRATIONS
AT SELECTED PACIFIC NORTHWEST LOCATIONS - 1960

Units of particles/m3 of Filtered Air

Date	Richland Washington	Spokane Washington	Boise Idaho	Hanford Project (200-W)	Klamath Falls Oregon	Lewiston Idaho	Walla Walla Washington	Yakima Washington
1-7	0.013	0.0076	0.0014	0.0070	0.0056	0.0065	< 0.0014	0.012
1-14	0.0081	0.0051	0.0014	0.0042	0.0014	< 0.0013	0.0014	0.0014
1-21	< 0.0021	0.0042	0.0029	0.0028	0.0042	< 0.0014	< 0.0014	0.0014
1-28	< 0.0008	0.0018	0.0026	0.0028	< 0.0016	0.0025	0.0012	0.0050
2-4	< 0.0008	< 0.0014	< 0.0015	< 0.0013	< 0.0014	< 0.0014	0.0014	< 0.0014
2-11	< 0.0014	0.0056	0.0028	< 0.0014	< 0.0014	< 0.0015	< 0.0014	0.0028
2-18	< 0.0014	0.0053	0.011	0.0070	< 0.0015	0.0028	0.0042	0.0042
2-25	0.0028	0.0077	0.014	0.017	0.029	0.014	0.011	0.011
3-3	0.0098	0.0074	0.0087	0.0084	0.011	0.026	0.014	0.0014
3-10	NA*	0.0058	0.040	0.017	0.012	0.0028	< 0.0014	0.0085
3-17	0.010	0.034	0.014	0.025	0.012	0.011	0.0062	0.025
3-24	NA	NA	0.032	0.071	NA	0.011	0.0065	0.016
3-31	NA	0.031	NA	0.010	0.0097	0.0070	NA	NA
4-7	0.0027	0.0028	0.0040	0.029	0.0021	0.0035	0.0028	0.0042
4-14	0.0058	0.0042	0.0014	0.010	0.0021	0.0035	0.0042	0.0042
4-21	0.0015	< 0.0014	< 0.0014	< 0.0042	< 0.0014	< 0.0025	0.0014	< 0.0014
4-28	< 0.0014	< 0.0014	0.0028	< 0.0014	< 0.0014	< 0.0016	0.0028	0.0014
5-5	< 0.0030	< 0.0014	< 0.0013	< 0.0070	< 0.0012	< 0.0014	< 0.0014	< 0.0014
5-12	< 0.0009	0.0042	< 0.0013	< 0.0014	< 0.0015	< 0.0014	< 0.0014	< 0.0014
5-19	< 0.0014	0.0014	0.0016	< 0.0014	0.0007	0.0014	< 0.0014	< 0.0007
5-26	0.0028	< 0.0014	0.0027	< 0.0014	0.0007	< 0.0015	0.0042	< 0.0007
6-2	< 0.0014	0.0042	< 0.0015	< 0.0042	0.0007	< 0.0012	< 0.0014	0.0028
6-9	0.0014	0.0014	0.0014	< 0.0070	0.0007	0.0066	0.0014	0.0036
6-16	0.0043	< 0.011	0.0014	0.012	0.0007	< 0.0015	< 0.0014	0.0033
6-23	< 0.0014	< 0.0014	0.0014		0.0007	0.0014	< 0.0010	< 0.0012
6-30			0.0014		0.0014	0.0043	0.0026	

*No Analysis

APPENDIX B
TABLE 1 (CONTINUED)

Date	Richland Washington	Spokane Washington	Boise Idaho	Hanford Project (200-W)	Klamath Falls Oregon	Lewiston Idaho	Walla Walla Washington	Yakima Washington
7-7	0.0066	0.0042	< 0.0012	0.0056	0.0014	0.0014	0.0042	0.0028
7-14	0.0066	0.015	0.0045	0.0014	0.0028	0.0058	0.0022	0.0042
7-21	< 0.0014	0.0042	0.0074	0.0042	< 0.0005	0.0014	0.0062	0.0014
7-28	0.0099	0.0084	0.0074	0.018	< 0.0005	0.0042	0.0070	0.0014
8-4	< 0.0014	0.0028	< 0.0010	0.0056	< 0.0005	0.0014	0.0014	< 0.0014
8-11	0.0028	< 0.0014	0.0025	0.0056	< 0.0011	0.0043	< 0.0014	0.0057
8-18	0.0014	0.0014	0.0027	0.011	0.0036	< 0.0013	0.0014	< 0.0014
8-25	< 0.0014	0.0028	< 0.0014	0.017	0.0036	0.0015	0.0014	0.0028
9-1	0.0035	< 0.0015	< 0.0014	0.0084	0.0033	0.0014	< 0.0014	0.0014
9-8	0.0025	0.0014	< 0.0010	0.015	< 0.0005	< 0.0014	< 0.0014	0.0004
9-15	0.0028	0.0014	0.0010	0.0042	< 0.0005	< 0.0014	0.0028	0.0004
9-22	< 0.0014	0.0029	0.0010	0.011	< 0.0010	< 0.0014	0.0014	0.0004
9-29	< 0.0014	0.0014	0.0010	0.0028	0.0010	< 0.0014	< 0.0014	0.0004
10-6	0.0007	< 0.0014	0.0015	0.014	0.0010	0.0014	< 0.0014	0.0029
10-13	0.0007	0.0014	0.0014	0.0097	0.0014	< 0.0014	0.0012	0.0029
10-20	NS	< 0.0014	0.0030	0.014	< 0.0014	0.0027	0.0016	< 0.0007
10-27	0.0005	0.0014	< 0.0025	0.018	0.0007	0.0029	0.0013	< 0.0007
11-3	0.0005	< 0.0014	0.0011	0.0028	0.0007	0.0015	< 0.0014	< 0.0005
11-10	0.0014	< 0.0014	< 0.0015	0.0085	0.0009	< 0.0014	< 0.0014	< 0.0005
11-17	0.0014	< 0.0014	0.0033	0.0042	0.0009	0.0015	< 0.0014	< 0.0005
11-24	< 0.0010	< 0.0014	< 0.0020	0.0042	0.0009	< 0.0014	0.0014	0.0005
12-1	< 0.0009	< 0.0014	0.0023	0.0071	< 0.0011	0.0029	0.0014	0.0005
12-8	< 0.0009	< 0.0014	< 0.0014	0.0070	< 0.0010	0.0028	0.0014	0.0005
12-15	< 0.0014	0.0028	0.0015	0.0028	< 0.0010	0.0014	0.0014	< 0.0014
12-22	0.0014	0.0014	0.0013	0.0056	< 0.0010	0.0014	< 0.0014	< 0.0014

APPENDIX B
TABLE 2

AVERAGE BETA ACTIVITY ON FILTERS
FROM SELECTED PACIFIC NORTHWEST LOCATIONS - 1960

Units of d/s per m3 of Filtered Air

Date	Richland Washington	Spokane Washington	Boise Idaho	Hanford Project (200-W)	Klamath Falls Oregon	Lewiston Idaho	Walla Walla Washington	Yakima Washington
1-7	1.3	0.56	0.75	1.7	0.83	0.67	1.2	1.2
1-14	0.90	0.39	0.47	1.2	0.10	0.29	0.55	0.50
1-21	0.50	0.54	0.52	1.1	0.32	0.41	0.62	0.52
1-28	0.31	0.33	0.76	2.1	0.46	0.54	0.68	0.54
2-4	0.36	0.20	0.64	0.71	0.22	0.34	0.34	0.18
2-11	0.28	0.20	0.59	0.46	0.14	0.26	0.26	0.13
2-18	0.31	0.29	0.57	0.68	0.34	0.24	0.27	0.16
2-25	0.53	0.42	0.65	0.98	0.90	0.78	0.88	0.37
3-3	NA*	0.25	0.85	1.1	0.53	0.71	0.72	0.44
3-10	NA	0.33	0.57	0.89	0.40	0.30	0.29	0.31
3-17	0.35	0.56	0.89	1.2	0.48	0.59	0.91	0.38
3-24	NA	NA	1.8	2.1	NA	1.7	1.5	1.0
3-31	NA	0.83	NA	1.1	1.2	0.42	NA	NA
4-7	0.32	0.38	0.18	0.98	0.37	0.73	0.53	0.30
4-14	0.85	0.73	0.88	1.0	0.37	0.73	0.87	0.72
4-21	0.47	0.42	0.78	0.78	0.42	0.42	0.55	0.38
4-28	0.37	0.27	1.0	2.5	0.52	0.52	0.52	0.40
5-5	0.48	0.40	0.57	0.45	0.27	0.42	0.37	0.28
5-12	0.38	0.35	0.58	1.1	0.42	0.62	0.42	0.32
5-19	0.48	0.43	0.90	0.52	0.27	0.55	0.52	0.27
5-26	0.35	0.30	0.80	0.98	0.27	0.27	0.42	0.27
6-2	0.30	0.55	0.65	0.70	0.27	0.18	0.33	0.18
6-9	0.52	0.53	0.68	0.87	0.27	0.57	0.48	0.32
6-16	3.4	0.53	0.57	1.3	0.15	0.90	0.78	0.53
6-23	0.28	0.32	0.73		0.15	0.67	0.43	0.32
6-30			0.63		0.23	0.42	0.72	

*No Analysis

APPENDIX B
TABLE 2 (CONTINUED)

Date	Richland Washington	Spokane Washington	Boise Idaho	Hanford Project (200-W)	Klamath Falls Oregon	Lewiston Idaho	Walla Walla Washington	Yakima Washington
7-7	0.48	0.42	0.84	0.95	NA*	0.73	0.60	0.43
7-14	0.48	0.63	0.75	0.90	0.89	0.67	0.60	0.42
7-21	0.38	0.53	0.35	0.80	0.28	0.50	0.87	0.35
7-28	0.38	0.58	0.35	1.5	0.28	0.50	0.37	0.33
8-4	0.28	0.15	0.33	0.94	0.28	0.28	0.40	0.32
8-11	0.43	0.27	0.58	1.1	0.40	0.58	0.57	0.43
8-18	0.23	0.37	0.45	0.65	0.25	0.28	0.27	0.20
8-25	0.12	0.25	0.30	0.62	0.17	0.18	0.32	0.20
9-1	0.37	0.20	0.35	0.63	0.17	0.25	0.25	0.23
9-8	0.45	0.22	0.45	0.50	0.17	0.23	0.37	0.20
9-15	0.33	0.35	0.22	0.85	0.17	0.37	0.37	0.20
9-22	0.33	0.27	0.22	1.0	0.18	0.27	0.27	0.20
9-29	0.37	0.20	0.22	1.0	0.12	0.22	0.30	0.20
10-6	0.30	0.42	0.47	0.94	0.12	0.30	0.25	0.18
10-13	0.30	0.15	0.18	1.2	0.23	0.10	0.17	0.18
10-20	NS	0.18	0.73	1.4	0.10	0.23	0.28	0.15
10-27	0.17	0.10	1.9	0.80	0.10	0.32	0.38	0.15
11-3	0.17	0.13	0.22	0.65	0.10	0.084	0.17	0.12
11-10	0.32	0.10	0.23	1.8	0.084	0.12	0.20	0.12
11-17	0.10	0.10	0.13	0.53	0.084	0.084	0.067	0.12
11-24	0.20	0.13	0.12	0.80	0.084	0.10	0.084	0.033
12-1	0.20	0.10	0.18	0.60	0.050	0.23	0.30	0.033
12-8	0.20	0.12	0.15	1.1	0.17	NA	0.10	0.033
12-15	1.1	0.12	0.42	2.1	0.17	0.33	1.6	0.27
12-22	0.37	0.17	0.17	0.52	0.17	0.017	0.30	0.27

*No Analysis

APPENDIX B
TABLE 3

ATMOSPHERIC CONCENTRATIONS OF I^{131}
AT PERIMETER COMMUNITIES - 1960
Units of 10^{-14} μc/cc of Scrubbed Air

Date	Richland Washington	North Richland Washington	Benton City Washington	Pasco Washington
12-28-59	6.8	34	84	1.9
1-4-60	1.8	7.0	16	2.0
1-11	7.1	4.2	13	3.9
1-18	8.5	22	11	4.6
1-25	22	6.8	3.5	4.1
2-1	5.1	5.6	5.6	1.8
2-8	1.7	3.8	5.3	3.8
2-15	0.8	1.8	1.1	2.0
2-22	3.3	3.9	2.7	1.3
2-29	2.5	2.4	1.0	3.6
3-7	1.6	1.0	2.7	1.6
3-14	0.1	0.7	0.8	0.7
3-21	4.5	5.7	7.2	5.0
3-28	2.0	2.9	4.0	1.1
4-4	0.5	0.1	2.1	1.6
4-11	1.8	2.3	1.0	2.2
4-18	2.1	6.2	0.7	< 0.1
4-25	4.9	1.7	0.9	1.0
5-2	2.3	2.3	1.0	1.4
5-9	1.3	1.1	2.5	0.6
5-16	0.5	3.0	2.2	1.3
5-23	0.9	0.4	< 0.1	0.4
5-31	0.6	1.0	0.4	0.1
6-6	1.5	1.5	0.6	2.2
6-13	2.6	2.2	1.3	1.3
6-20	0.7	2.5	< 0.1	3.3

APPENDIX B
TABLE 3 (CONTINUED)

Date	Richland Washington	North Richland Washington	Benton City Washington	Pasco Washington
6-27	1.5	1.5	2.9	1.1
7-6	< 0.1	2.7	4.4	1.9
7-11	< 0.1	2.5	4.2	3.8
7-18	1.9	3.2	2.2	2.0
7-25	3.8	2.9	2.2	3.1
8-1	1.4	NA*	1.3	1.4
8-8	1.0	2.2	1.4	1.4
8-15	3.9	5.0	1.0	1.8
8-22	4.9	3.0	0.1	3.1
8-29	2.1	5.3	1.7	1.2
9-8	1.0	7.4	4.2	3.9
9-12	13	14	12	4.6
9-19	4.2	NA	2.6	6.0
9-26	2.2	4.8	5.2	2.7
10-3	1.5	0.8	1.0	1.9
10-10	2.1	1.5	1.9	0.6
10-17	5.0	7.0	2.3	5.7
10-24	3.9	1.9	3.5	0.4
10-31	2.0	1.7	2.9	1.4
11-7	1.6	2.4	2.2	2.3
11-14	0.5	1.2	1.2	2.5
11-21	0.6	2.1	3.8	0.9
11-28	1.6	2.2	2.4	2.4
12-5	1.3	2.0	4.7	1.1
12-12	3.2	14	31	5.6

*No Analysis

APPENDIX B
TABLE 4

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
BENTON CITY, WASHINGTON AND VICINITY, ZONE I - 1960

Units of 10^{-6} $\mu c/g$ of Vegetation

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-5	-	-	3.6	6.0	-
1-12	-	-	3.0	8.4	9.1
1-19	-	-	3.9	6.9	18
1-26	-	-	4.2	6.7	-
2-2	-	-	4.2	3.1	5.1
2-9	-	-	4.3	3.0	8.3
2-16	-	-	4.7	-	17
2-23	-	-	3.1	-	21
3-1	-	-	4.2	-	12
3-8	-	-	5.5	-	18
3-15	-	-	-	-	9.7
3-22	-	-	2.7	-	-
3-29	-	-	3.2	-	7.1
4-5	-	-	2.2	-	-
4-12	-	-	-	-	-
4-19	-	-	-	-	-
4-26	-	-	-	-	6.4
5-3	-	-	3.0	-	7.6
5-10	-	-	-	-	-
5-17	-	-	-	-	-
5-24	-	-	-	-	-
6-1	-	-	-	-	-
6-7	-	-	-	-	-
6-14	-	-	2.8	-	7.3
6-21	-	-	-	-	8.5
6-28	-	-	-	-	52

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 4 (CONTINUED)

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
7-6	-	-	-	-	-
7-13	-	-	-	-	5.7
7-19	-	-	-	-	6.1
7-26	-	-	-	-	-
8-2	-	-	-	-	6.1
8-9	-	-	2.4	-	8.5
8-16	-	-	-	-	8.6
8-23	2.1	-	-	-	-
8-30	-	-	-	-	8.5
9-8	-	-	-	-	7.7
9-13	-	-	-	-	-
9-20	-	-	3.7	-	9.6
9-27	-	-	-	-	9.9
10-4	-	-	-	-	5.1
10-11	-	-	2.0	-	5.5
10-18	-	-	-	-	-
10-25	2.0	-	-	-	-
11-1	-	-	-	-	9.8
11-8	-	-	-	-	12
11-15	-	-	-	-	8.3
11-29	-	-	2.7	-	10
12-6	-	-	-	-	-
12-13	-	-	-	6.5	5.1
12-20	-	-	2.5	4.5	6.3

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 5

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
RICHLAND, WASHINGTON AND VICINITY, ZONE K - 1960
Units of 10^{-6} $\mu c/g$ of Vegetation

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-6	-	-	2.7	3.9	13
1-13	-	-	-	4.5	-
1-20	-	-	-	4.0	13
1-28	3.8	4.3	11	7.4	41
2-3	-	-	-	-	8.9
2-10	-	-	4.5	3.4	11
2-17	-	-	6.5	-	-
2-24	-	-	3.1	1.9	11
3-2	2.1	-	2.9	-	12
3-9	-	-	5.4	-	7.3
3-16	-	-	4.4	-	7.6
3-23	-	-	-	-	5.3
3-30	-	-	-	-	8.7
4-6	-	-	-	-	5.5
4-13	-	-	-	-	-
4-20	-	-	-	-	-
4-27	-	-	-	-	-
5-4	-	-	-	-	-
5-11	-	-	-	-	-
5-18	-	-	-	-	-
5-25	-	-	-	-	7.2
6-1	-	-	-	-	-
6-8	-	-	2.2	-	-
6-15	-	-	-	-	-
6-22	-	-	-	-	7.0
6-29	-	-	-	-	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 5 (CONTINUED)

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
7-6	-	-	2.4	-	-
7-12	-	-	-	-	5.3
7-20	-	-	-	-	-
7-27	-	-	-	-	5.6
8-3	-	-	-	-	5.0
8-10	-	-	-	-	11
8-17	-	-	3.0	-	-
8-24	-	-	2.6	-	5.0
8-31	-	-	-	-	9.2
9-7	2.4	-	-	-	7.6
9-14	-	-	-	-	9.5
9-21	-	-	2.3	-	-
9-28	-	-	2.1	-	-
10-5	-	-	-	-	7.6
10-12	-	-	2.5	-	-
10-19	-	-	-	-	-
10-26	-	-	-	-	-
11-2	-	-	-	-	-
11-9	-	-	-	-	-
11-16	-	-	-	-	-
11-23	-	-	-	-	7.4
11-30	-	-	-	-	-
12-7	-	-	-	-	-
12-21	-	-	-	2.8	7.4

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 6

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
KENNEWICK, WASHINGTON AND VICINITY, ZONE L - 1960

Units of 10^{-6} μc/g of Vegetation

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-5	-	-	-	-	20
1-12	-	2.6	4.3	2.5	18
1-19	-	-	3.0	-	16
1-26	-	-	2.5	1.5	-
2-2	-	-	4.4	-	17
2-9	-	-	-	2.6	8.8
2-16	-	-	5.7	2.1	-
2-23	2.9	-	-	-	24
3-1	2.3	-	5.3	-	22
3-8	-	-	6.5	-	13
3-15	-	-	-	-	6.0
3-22	-	-	3.4	-	7.6
3-29	-	-	2.1	-	10
4-5	-	-	-	-	-
4-12	2.2	-	-	-	6.2
4-19	-	-	2.4	-	7.1
4-26	-	-	-	-	-
5-3	-	-	-	-	-
5-10	-	-	-	-	-
5-17	-	-	-	-	-
5-24	-	-	-	-	-
5-31	-	-	-	-	-
6-7	-	-	-	-	-
6-14	-	-	-	-	-
6-21	-	-	-	-	5.0
6-28	-	-	-	-	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 6 (CONTINUED)

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
7-6	-	-	-	-	-
7-11	-	-	-	-	9.0
7-19	-	-	2.2	-	-
7-26	-	-	-	-	-
8-2	-	-	-	-	7.8
8-8	-	-	-	-	7.9
8-16	-	-	-	-	5.1
8-23	-	-	-	-	5.1
8-30	-	-	2.2	-	6.4
9-6	-	-	-	-	9.6
9-13	-	-	-	-	7.7
9-20	-	-	-	-	-
9-27	-	-	-	-	5.8
10-4	-	-	-	-	-
10-11	-	-	-	-	5.8
10-18	-	-	-	-	-
10-25	-	-	-	-	-
11-1	-	-	-	-	5.1
11-8	-	-	2.4	-	8.9
11-15	-	-	-	-	6.2
11-22	-	-	-	-	5.5
11-29	-	-	-	-	9.2
12-6	-	-	-	-	5.4
12-20	-	-	-	2.1	9.7

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 7

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
PASCO TO ELTOPIA, WASHINGTON, ZONE M - 1960

Units of 10^{-6} μc/g of Vegetation

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-5	-	-	3.2	2.3	17
1-12	-	-	-	1.5	11
1-19	-	-	3.6	1.7	14
1-26	-	2.2	15	9.9	6.6
2-2	-	-	2.6	-	19
2-9	-	-	-	1.7	13
2-16	-	3.0	9.8	1.7	12
2-23	-	-	6.1	-	13
3-1	-	-	4.5	-	25
3-8	2.6	-	4.6	-	7.6
3-15	-	-	4.5	-	12
3-22	-	-	2.7	-	8.9
3-29	-	-	-	-	8.9
4-5	-	-	-	-	-
4-12	2.3	-	-	2.5	9.2
4-19	2.4	-	-	-	-
4-26	-	-	-	-	-
5-3	-	-	-	-	-
5-10	-	-	-	-	-
5-17	-	-	-	-	-
5-24	-	-	-	-	5.1
5-31	-	-	-	-	6.7
6-7	-	-	-	-	-
6-14	-	-	-	-	-
6-21	-	-	-	-	-
6-28	-	-	-	-	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 7 (CONTINUED)

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
7-6	-	-	-	-	-
7-11	-	-	2.4	-	9.3
7-19	-	-	-	-	5.2
7-26	-	-	-	-	-
8-2	-	-	-	-	9.5
8-8	-	-	-	-	7.3
8-16	-	-	-	-	7.6
8-23	-	-	-	-	9.9
8-30	-	-	-	-	7.0
9-6	-	-	-	-	10
9-13	-	-	-	-	5.8
9-20	-	-	-	-	6.8
9-27	-	-	-	-	7.3
10-4	-	-	-	-	6.3
10-11	-	-	-	-	6.8
10-18	-	-	-	-	7.2
10-25	-	-	2.4	-	-
11-1	-	-	-	-	-
11-8	-	-	2.7	-	7.2
11-15	-	-	-	-	14
11-22	-	-	-	-	9.4
11-29	-	-	2.9	-	6.3
12-6	-	-	-	-	-
12-20	-	-	-	4.0	8.5

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 8

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
MESA, WASHINGTON AND VICINITY, ZONE N - 1960

Units of 10^{-6} μc/g of Vegetation

Date	$Ba^{140}-La^{140}$	$Zr^{95}-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-5	-	-	3.0	-	16
1-12	-	-	-	2.5	9.0
1-19	-	-	2.7	2.0	-
1-26	-	-	4.6	2.0	13
2-2	-	-	-	-	9.8
2-9	-	-	-	-	13
2-16	-	-	5.3	-	5.8
2-23	-	-	4.8	1.7	17
3-1	-	-	-	-	9.6
3-8	-	-	4.8	-	14
3-15	-	-	2.8	-	7.4
3-22	-	-	-	-	7.4
3-29	-	-	2.6	-	7.7
4-5	-	-	-	-	-
4-12	-	-	2.7	-	7.2
4-19	-	-	-	-	-
4-26	-	-	-	-	-
5-3	-	-	-	-	-
5-10	-	-	-	-	-
5-17	-	-	-	-	-
5-24	-	-	-	-	-
5-31	-	-	-	-	-
6-7	-	-	-	-	-
6-14	-	-	-	-	-
6-21	-	-	-	-	-
6-28	-	-	-	-	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 8 (CONTINUED)

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
7-6	-	-	-	-	-
7-11	-	-	-	-	-
7-19	-	-	-	-	5.0
7-26	-	-	-	-	6.1
8-2	-	32	3.4	1.9	28
8-8	2.4	-	-	-	6.9
8-16	-	-	-	-	6.7
8-23	-	-	-	-	7.2
8-30	-	-	4.6	-	-
9-6	-	-	2.4	1.5	7.4
9-13	-	-	-	-	-
9-20	-	-	-	-	5.4
9-27	-	-	-	-	10
10-4	-	-	-	-	-
10-11	-	-	-	-	-
10-18	-	-	-	-	6.0
10-25	-	-	-	-	-
11-1	-	-	-	-	5.0
11-8	-	-	-	-	6.7
11-15	-	-	-	-	8.5
11-22	-	-	2.0	-	9.8
11-29	-	-	2.5	-	10
12-6	-	-	-	-	-
12-20	-	-	-	1.7	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 9

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
WAHLUKE SLOPE EAST, ZONE 0 - 1960

Units of 10^{-6} $\mu c/g$ of Vegetation

Date	$Ba^{140}-La^{140}$	$Zr^{95}-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-4	-	2.0	6.9	2.1	11
1-11	-	-	6.7	3.2	16
1-18	-	-	6.6	3.4	9.3
1-25	-	-	4.6	3.7	8.9
2-1	-	-	3.2	3.2	12
2-8	-	-	-	-	11
2-15	-	-	4.2	1.6	17
2-22	-	-	-	-	9.6
2-29	-	-	6.7	-	14
3-7	2.4	-	5.2	-	16
3-14	-	-	3.6	-	11
3-21	-	-	3.0	-	7.4
3-28	-	-	-	-	-
4-4	-	-	-	-	-
4-11	-	-	-	-	-
4-18	-	-	-	2.1	6.5
4-25	-	-	3.2	-	7.7
5-2	-	-	-	-	6.1
5-9	-	-	-	-	-
5-16	-	-	-	-	6.1
5-23	-	-	2.4	-	8.2
5-31	-	-	-	-	-
6-6	-	-	2.5	-	-
6-13	-	-	2.0	-	-
6-20	-	-	-	-	5.8
6-27	-	-	-	-	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 9 (CONTINUED)

Date	$Ba^{140}-La^{140}$	$Zr^{95}-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
7-5	-	-	-	-	5.8
7-11	-	-	-	-	8.4
7-18	-	-	-	-	7.0
7-25	-	-	2.9	-	6.2
8-1	-	-	2.5	-	-
8-8	-	-	-	-	7.4
8-15	-	-	12	-	14
8-22	-	-	2.2	1.5	12
8-29	-	-	-	-	10
9-6	-	-	-	-	6.7
9-12	-	-	-	-	-
9-19	-	-	4.7	-	12
9-26	-	-	3.0	-	12
10-3	-	-	2.7	-	15
10-10	-	-	2.9	-	6.5
10-17	-	-	-	-	11
10-24	-	-	3.4	-	9.8
10-31	-	3.6	-	-	20
11-7	-	-	3.3	-	10
11-14	-	-	-	-	7.3
11-21	-	-	-	-	6.4
11-29	-	-	3.7	-	8.4
12-12	-	-	-	3.2	12
12-29	-	-	2.8	1.6	7.7

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 10

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
WAHLUKE SLOPE WEST, ZONE P - 1960

Units of 10^{-6} μc/g of Vegetation

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-4	-	-	2.5	2.3	12
1-11	-	2.5	5.9	4.8	9.3
1-18	-	2.1	2.8	5.3	14
1-25	-	-	3.7	6.7	12
2-1	-	-	2.7	4.2	13
2-4	-	-	2.2	2.6	12
2-15	-	-	-	-	17
2-22	-	-	6.1	1.5	14
2-29	-	-	4.9	-	22
3-7	2.0	-	3.4	-	18
3-14	-	-	2.2	-	11
3-21	-	-	2.0	-	7.1
3-28	-	-	-	-	-
4-4	-	-	-	-	6.6
4-11	-	-	-	-	7.7
4-18	2.0	-	-	-	5.2
4-25	-	-	-	-	8.3
5-2	-	-	-	-	6.9
5-9	-	-	4.5	-	5.1
5-16	-	-	-	-	7.9
5-23	-	-	-	-	7.1
5-31	-	-	-	-	5.2
6-6	-	-	2.0	-	12
6-13	-	-	2.5	-	6.7
6-20	-	-	2.2	-	-
6-27	-	-	-	-	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 10 (CONTINUED)

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
7-5	-	-	-	-	-
7-11	-	-	2.3	-	-
7-18	-	-	-	-	-
7-25	-	-	3.7	-	-
8-1	-	-	-	-	7.0
8-8	-	-	2.4	-	6.9
8-15	-	-	4.2	-	6.1
8-22	-	-	-	-	10
8-29	-	-	-	-	8.9
9-6	-	-	-	-	8.7
9-12	-	-	-	-	7.3
9-19	-	-	2.7	-	10
9-26	-	-	-	-	10
10-3	-	-	-	-	11
10-10	-	-	3.2	-	-
10-17	-	-	2.0	-	6.4
10-24	-	-	2.8	-	11
10-31	-	-	-	-	9.9
11-7	-	-	3.0	-	8.2
11-14	-	-	-	-	8.3
11-21	-	-	2.2	-	-
11-29	-	-	-	-	6.6
12-12	-	-	2.0	2.4	6.1
12-20	-	-	-	7.0	12
12-29	-	-	-	2.3	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 11

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
HORSE HEAVEN HILLS, ZONE Q - 1960

Units of 10^{-6} μc/g of Vegetation

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-6	-	-	4.8	4.4	16
1-13	-	-	2.1	1.8	9.4
1-20	-	-	5.1	6.0	7.1
1-27	2.7	2.3	5.3	6.3	22
2-3	-	-	5.1	1.9	14
2-10	-	2.0	4.9	1.7	21
2-17	-	-	4.2	1.6	14
2-24	-	-	4.3	-	14
3-2	-	-	6.4	-	21
3-8	-	-	5.8	-	14
3-16	-	-	3.4	-	9.7
3-22	-	-	-	-	-
3-30	-	-	3.1	-	10
4-6	-	-	-	-	-
4-13	-	-	-	-	-
4-20	-	-	2.1	-	6.5
4-27	-	-	-	-	-
5-4	-	-	-	-	-
5-11	-	-	-	-	-
5-18	-	-	-	-	-
5-25	-	-	3.0	-	9.3
6-1	-	-	-	-	7.6
6-8	-	-	-	-	-
6-15	-	-	-	-	6.4
6-22	-	-	-	-	5.0
6-29	-	-	-	-	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 11 (CONTINUED)

Date	$Ba^{140}-La^{140}$	$Zr^{95}-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
7-6	-	-	-	-	-
7-12	-	-	-	-	5.1
7-19	-	-	-	-	-
7-27	-	-	-	-	-
8-3	-	-	2.0	-	6.8
8-10	2.0	-	-	-	11
8-17	-	-	2.0	-	7.2
8-24	-	-	-	-	10
8-31	-	-	-	-	7.3
9-7	-	-	2.7	-	5.9
9-11	-	-	-	-	10
9-21	-	-	-	-	6.9
10-4	-	-	-	-	6.0
10-12	-	-	2.4	-	7.3
10-19	-	-	-	-	-
10-26	-	-	-	-	6.9
11-2	-	-	-	-	7.5
11-9	-	-	2.5	-	5.4
11-16	-	-	-	-	9.9
11-23	-	-	-	-	6.0
11-30	-	-	2.1	-	11
12-7	-	-	-	-	8.6

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 12

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
WALLA WALLA, WASHINGTON AND VICINITY, ZONE R - 1960

Units of 10^{-6} μc/g of Vegetation

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-11	-	-	4.7	-	16
2-2	-	-	4.1	-	18
3-3	-	-	3.8	-	19
4-12	-	-	-	-	-
5-24	-	-	-	-	-
6-29	-	-	-	-	-
8-2	4.0	-	-	-	-
8-30	-	-	-	-	15
11-1	-	-	-	-	8.1

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 13

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
LEWISTON, IDAHO AND VICINITY, ZONE S - 1960
Units of 10^{-6} μc/g of Vegetation

Date	$Ba^{140}-La^{140}$	$Zr^{95}-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-11	-	-	2.4	-	16
2-2	-	-	5.0	-	25
3-3	-	-	6.8	-	24
4-12	-	-	2.7	-	-
5-24	-	-	2.8	-	5.1
6-29	2.1	-	-	-	-
8-2	-	-	-	-	-
8-30	-	-	-	-	6.8
11-1	-	-	-	-	7.3

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 14

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
SPOKANE, WASHINGTON AND VICINITY, ZONE T - 1960
Units of 10^{-6} μc/g of Vegetation

Date	$Ba^{140}-La^{140}$	$Zr^{95}-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-11	-	3.3	3.3	-	31
2-3	-	2.3	6.7	1.6	36
3-3	-	-	4.9	-	21
4-12	-	-	-	-	-
5-25	-	-	-	-	-
6-29	-	-	-	-	-
8-3	3.7	-	-	-	-
8-30	-	-	-	-	-
11-2	-	-	2.0	-	8.1

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 15

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
RITZVILLE, WASHINGTON AND VICINITY, ZONE U - 1960

Units of 10^{-6} μc/g of Vegetation

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-11	-	-	3.0	-	14
2-3	2.7	-	-	1.8	18
3-3	-	-	6.1	-	16
4-13	-	-	-	-	-
5-25	-	-	2.5	-	5.3
6-30	-	-	-	-	-
8-3	-	-	-	-	-
8-31	-	-	3.0	-	11
11-2	-	-	-	-	6.3

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 16

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
TOPPENISH, WASHINGTON AND VICINITY, ZONE V - 1960

Units of 10^{-6} μc/g of Vegetation

Date	$Ba^{140}-La^{140}$	$Zr^{95}-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-6	-	-	-	-	-
2-9	-	-	-	2.3	9.4
3-8	-	-	-	-	8.0
4-5	-	-	-	-	-
5-3	-	-	-	-	5.0
6-7	-	-	-	-	-
7-12	-	-	-	-	-
8-9	-	-	-	-	8.2
9-13	-	-	-	-	6.2
10-12	-	-	-	-	6.2
11-9	2.4	-	-	-	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 17

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
GOLDENDALE, WASHINGTON AND VICINITY, ZONE W - 1960

Units of 10^{-6} $\mu c/g$ of Vegetation

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-6	-	-	-	-	20
2-9	-	2.9	7.7	-	32
3-8	-	-	6.3	-	25
4-5	-	-	-	-	-
5-3	-	-	-	-	-
6-7	-	-	2.4	-	6.6
7-12	-	-	-	-	-
8-9	-	-	-	-	8.4
9-13	-	-	-	-	6.7
10-12	-	-	-	-	13
11-9	-	-	-	-	5.0

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 18

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
PORTLAND TO BONNEVILLE, OREGON, ZONE X - 1960

Units of 10^{-6} $\mu c/g$ of Vegetation

Date	Ba^{140}-La^{140}	Zr^{95}-Nb^{95}	Ru^{103}+Ru^{106}	I^{131}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-6	-	2.2	6.6	-	14
2-9	-	-	7.4	-	30
3-9	-	-	5.6	-	14
4-5	-	-	3.2	-	14
5-4	-	-	-	-	-
6-7	-	-	-	-	-
7-12	-	-	-	-	-
8-9	-	-	-	-	7.1
9-14	-	-	-	-	6.1
10-13	-	-	-	-	10
11-9	-	-	3.9	-	9.0

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 19

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
THE DALLES TO BOARDMAN, OREGON, ZONE Y - 1960

Units of 10^{-6} μc/g Vegetation

Date	$Ba^{140}-La^{140}$	$Zr^{95}-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1-6	-	-	2.7	-	16
2-10	-	-	2.7	-	14
3-9	2.9	-	2.5	-	11
4-6	-	-	-	-	8.1
5-4	-	-	-	-	-
6-8	-	-	-	-	-
7-12	-	-	-	-	-
8-10	2.7	-	-	-	6.9
9-14	-	-	-	-	7.8
10-13	-	-	2.5	-	-
11-9	-	-	-	-	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 20

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
RIVERVIEW DISTRICT OF PASCO, WASHINGTON, ZONE Z - 1960

Units of 10^{-6} $\mu c/g$ of Vegetation

Date	Ba^{140}-La^{140}	Zn^{65}	Zr^{95}-Nb^{95}	Cs^{137}	Ru^{103}+Ru^{106}	I^{131}	Cr^{51}	Ce^{141}+Ce^{144}
Reporting Limits*	2.0	1.5	2.0	1.0	2.0	1.5	5.0	5.0
1-5	-	-	-	-	-	-	-	7.0
1-12	-	-	2.0	1.6	2.7	3.1	-	12
1-19	-	-	-	1.2	2.4	2.4	-	11
1-26	-	2.4	-	1.0	5.2	2.2	-	7.7
2-2	-	-	-	2.1	3.3	2.4	-	18
2-10	-	-	-	1.6	-	1.8	-	13
2-16	-	6.6	-	1.5	4.6	-	-	14
2-23	-	-	-	1.9	-	-	-	13
3-1	2.9	-	-	2.2	5.4	-	-	34
3-8	-	2.7	-	-	5.1	-	-	11
3-16	-	2.2	-	-	-	-	-	6.5
3-22	-	-	-	-	-	-	-	7.7
3-29	-	-	-	-	-	-	-	-
4-5	-	-	-	-	-	-	-	-
4-12	2.6	2.0	-	-	-	-	-	6.5
4-19	-	3.5	-	-	-	-	-	-
4-26	-	1.8	-	-	-	-	-	-
5-3	-	2.6	-	-	-	-	-	-
5-10	-	1.5	-	-	-	-	-	-
5-17	-	3.0	-	-	-	-	-	-
5-24	-	1.8	-	-	-	-	-	-
5-31	-	2.7	-	-	-	-	-	-
6-7	-	-	-	-	-	-	-	-
6-14	-	1.7	-	-	2.6	-	-	-
6-21	-	1.7	-	-	-	-	-	-
6-28	-	1.6	-	-	-	-	-	-

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 20 (CONTINUED)

Date	$Ba^{140}-La^{140}$	Zn^{65}	$Zr^{95}-Nb^{95}$	Cs^{137}	$Ru^{103}+Ru^{106}$	I^{131}	Cr^{51}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	1.5	2.0	1.0	2.0	1.5	5.0	5.0
7-6	-	4.1	-	-	-	-	-	-
7-11	-	4.7	-	-	-	-	-	-
7-19	-	1.5	-	-	-	-	-	-
7-26	-	2.0	-	-	-	-	-	-
8-2	-	-	-	-	-	-	-	5.4
8-10	-	4.5	-	-	-	-	-	-
8-16	-	1.9	-	-	-	-	-	7.7
8-23	-	6.0	-	-	-	-	-	6.3
8-30	-	-	-	-	-	-	-	8.9
9-6	-	2.3	-	-	-	-	-	8.7
9-13	-	1.8	-	-	-	-	-	-
9-20	-	2.3	-	-	2.6	-	-	15
9-27	-	4.5	-	-	-	-	6.3	-
10-4	-	8.0	-	-	-	-	-	8.8
10-11	-	4.1	-	-	-	-	-	5.0
10-18	-	2.8	-	-	-	-	-	7.2
10-25	-	3.1	-	-	-	-	-	-
11-1	-	2.0	-	-	-	-	-	-
11-8	-	-	-	-	2.4	-	5.7	-
11-15	-	7.9	-	-	-	-	-	8.3
11-22	-	1.9	-	1.0	-	-	-	9.5
11-29	-	2.3	-	-	-	-	-	6.4

*Analytical results below reporting limits are indicated by a (-).

APPENDIX B
TABLE 21

QUANTITY OF I^{131} RELEASED FROM THE SEPARATIONS AREAS' PROCESS STACKS -1960

Units of curies/day

Day of Month	January	February	March	April	May	June	July	August	September	October	November	December
1	1.2	0.026	0.22	0.52	0.80	0.23	0.50	0.34	1.6	0.10	0.69	0.66
2	1.2	0.13	0.11	0.76	1.0	0.16	0.64	0.38	2.2	NS	0.80	0.51
3	1.2	0.085	0.16	0.76	1.5	0.19	3.5	0.61	2.2	0.12	0.49	0.51
4	1.2	0.41	0.097	0.69	1.7	0.26	3.5	0.94	2.2	0.12	0.43	0.51
5	1.1	0.97	0.057	0.55	1.3	0.26	19	1.2	2.8	0.066	0.43	1.1
6	1.1	1.4	0.058	0.55	1.5	0.82	14	1.2	2.8	0.041	0.43	0.57
7	1.1	1.4	0.12	0.67	1.5	1.3	5.2	1.2	3.7	0.028	0.42	2.1
8	1.1	1.2	0.10	0.57	1.5	1.2	3.5	1.6	7.2	0.028	0.50	2.0
9	1.1	1.0	0.18	0.46	1.2	0.36	3.5	1.4	2.6	0.028	0.36	3.1
10	1.1	0.48	0.083	0.46	1.0	0.36	3.5	1.6	2.6	0.026	0.36	3.9
11	1.1	0.50	0.015	0.53	0.76	0.77	2.6	1.4	2.6	0.021	0.61	3.9
12	0.85	1.0	0.015	0.78	0.26	0.77	2.2	2.2	3.0	0.022	1.2	2.9
13	1.1	1.0	0.014	0.55	0.24	0.70	1.6	2.2	2.3	0.15	1.2	2.4
14	1.3	1.0	0.038	0.44	0.19	0.44	1.6	2.2	2.3	0.065	0.87	2.6
15	1.7	1.3	0.16	1.2	0.19	0.51	1.1	3.3	1.6	0.015	0.88	2.2
16	1.7	1.6	0.57	1.4	0.18	1.2	1.1	3.5	1.2	0.015	1.1	1.5
17	1.7	1.6	0.40	1.4	0.15	0.45	1.1	2.2	1.8	0.023	1.3	1.5
18	1.0	1.5	0.052	0.80	0.21	0.51	1.4	2.3	1.8	0.035	1.7	1.5
19	0.84	0.53	0.052	0.83	0.45	0.51	1.1	2.4	1.7	0.023	1.2	1.4
20	0.84	0.025	0.042	0.84	0.84	0.38	0.87	2.0	1.3	0.022	1.2	1.0
21	1.3	0.024	0.24	0.63	0.84	0.29	1.2	2.0	0.63	0.018	1.6	0.45
22	1.4	0.47	0.054	0.66	0.18	0.23	0.97	1.2	0.44	0.018	1.4	1.1
23	1.5	0.41		0.52	0.15	0.24	1.1	0.56	0.51	0.018	1.1	0.23
24	1.5	0.070	0.30	0.52	0.071	0.17	1.1	1.2	0.40	0.037	1.1	0.049
25	0.90	0.032	0.10	0.51	0.077	0.17	1.1	1.4	0.40	0.046	0.85	0.049
26	1.1	0.084	0.10	0.43	0.061	0.17	1.3	1.5	0.29	0.15	0.67	0.049
27	1.0	0.084	0.10	0.53	0.082	0.71	0.94	1.5	0.23	0.84	0.67	0.042
28	0.92	0.083	0.79	0.44	0.11	0.29	0.79	1.5	0.17	0.23	0.25	0.040
29	1.1	0.20	0.60	0.55	0.14	0.33	0.63	2.1	0.16	0.90	0.11	0.075
30	0.31		0.58	0.80	0.14	0.68	0.63	2.2	0.10	0.90	0.46	0.58
31	0.31		0.56		0.37		0.63	2.1		0.95		

APPENDIX B
TABLE 22

I^{131} IN BEEF CATTLE THYROIDS FROM
CATTLE SLAUGHTERED AT PASCO, WASHINGTON - 1960
Units of 10^{-6} μc/gm of Thyroids

Date Sampled	Thyroid Wt (gm)	μc I^{131} Concentration
9-8	15.7	30
9-8	14.4	1.3
9-8	22.8	1.3
9-8	23.9	200
9-16	6.4	16
9-16	17.9	110
9-16	8.7	4.8
9-16	16.2	11
9-22	20.3	8.9
9-22	25.6	2.4
9-22	35.8	0.76
9-22	22.8	2.0
9-22	30.8	63
9-22	24.2	35
9-24	21.3	230
9-24	22.6	30
9-24	20.0	30
9-24	27.8	6.1
10-7	18.4	8.3
10-7	30.2	4.3
10-7	29.2	75
10-7	32.3	25
10-7	19.8	1.3
10-7	26.8	1.0
10-20	18.5	8.0
10-20	21.5	72
10-20	26.2	< 1
10-20	38.0	18
10-20	20.0	22
11-26	35.2	27
11-26	54.0	18
12-1	16.9	2.8
12-1	30.4	48
12-1	18.2	11
12-1	21.3	2.2
12-1	12.9	5.7
12-8	24.0	31
12-8	28.8	0.9
12-8	27.9	2.5
12-8	32.8	3.5
12-8	24.2	4.0
12-16	33.4	7.9
12-16	33.0	1000
12-16	13.9	160
12-16	8.8	41
12-16	15.6	8.7
12-16	15.3	29
12-16	21.6	83

APPENDIX C
TABLE 1

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN MILK
PURCHASED FROM PRODUCERS AT SELECTED LOCATIONS - 1960

Units of 10^{-6} $\mu c/gm$

Date	K^{40}	Zn^{65}	Cs^{137}	I^{131}	Sr^{90}	P^{32}
Reporting Limits*	0.3	0.08	0.03	0.05	0.002	0.1
Riverview Irrigation District (Farm 2)						
1-5	1.4	0.63	-	-	0.0030	-
1-12	1.4	0.66	-	-	0.0057	-
1-26	Lost				0.0062	-
2-2	0.87	0.12	-	-	Lost	
2-9	0.58	0.098	-	-	0.0051	NA***
2-16	1.3	0.084	-	-	0.0064	NA
2-23	1.2	0.11	-	-	Lost	
3-1	1.1	0.12	-	-	0.0056	0.13
3-30	2.0	0.10	0.059	-	0.0042	0.13
5-3	1.6	-	0.035	-	0.0057	-
5-24	1.6	0.53	-	-	0.0040	1.4
6-22	1.5	0.96	-	-	0.0031	1.2
7-8	1.1	0.78	-	-	Not Analyzed	
7-11	1.5	0.73	-	-	"	"
7-13	1.1	0.73	-	-	"	"
7-14	0.98	0.73	-	-	"	"
7-26	1.3	0.77	-	-	0.0030	0.72
8-9	1.4	0.64	-	-	0.0027	0.85
9-6	1.5	0.68	-	-	0.0051	0.92
9-13	1.2	0.75	-	-	0.0040	1.0
9-20	1.7	0.78	0.065	0.074	0.0026	1.1
9-27	1.7	0.90	0.032	-	0.0076	1.1
10-4	1.4	0.55	-	-	0.0032	0.36
10-11	1.7	0.37	-	-	0.0021	0.23
10-25	1.5	0.63	-	-	0.0029	0.44
11-1	1.2	0.68	-	-	0.0037	0.33
11-8 **					0.0021	0.18
11-15 **					0.0033	0.14
11-22 **					0.0021	-
11-23 **					-	-
12-8	0.94	0.21	0.054	0.12	0.0032	-
12-13	1.6	0.17	0.045	-	0.0021	-
12-22	1.5	0.22	-	-	0.0021	-
12-28	1.2	0.16	-	-	0.0029	-

*Results less than the reporting limit are indicated by a (-).
**Gamma scan lost.
***Not Analyzed.

APPENDIX C
TABLE 1 (CONTINUED)

Date	K^{40}	Zn^{65}	Cs^{137}	I^{131}	Sr^{90}	P^{32}
Reporting Limits*	0.3	0.08	0.03	0.05	0.002	0.1
Riverview Irrigation District (Farm 3)						
1-20	1.2	0.56	-	-	0.0077	-
1-26	1.1	0.35	-	-	0.0062	-
2-9	0.44	0.33	-	-	0.0058	NA***
2-16	1.2	0.39	0.030	-	0.0048	NA
2-23	1.2	0.33	-	-	0.0033	NA
Ringold Farms						
2-8	0.70	0.28	-	-	0.0022	NA
2-16	1.2	0.28	-	-	0.0023	"
2-23	1.2	0.45	-	-	0.0021	"
3-1	1.3	0.45	-	-	0.0036	0.27
3-31	1.5	0.36	-	-	0.0044	0.27
4-26	1.6	0.50	-	-	0.0043	0.14
5-27	1.6	0.80	-	-	0.0035	Lost
6-22	1.5	0.58	-	-	Lost	0.35
7-8	0.93	0.60	-	-	Not Analyzed	
7-13	0.84	0.54	-	-	" "	
7-14	0.88	0.51	0.096	-	" "	
7-26	0.95	0.47	-	-	0.0021	0.62
8-9	0.70	0.46	-	-	0.0027	0.64
8-17	1.2	0.32	0.039	-	0.0066	1.2
8-24	1.6	0.65	-	0.10	0.0025	1.1
8-24	1.7	0.63	-	0.07	0.0028	1.5
8-31	1.2	0.83	-	0.09	0.0025	1.4
9-7	1.0	0.82	-	-	0.0022	1.2
9-21	1.6	0.97	-	-	0.0029	2.1
9-28	1.8	0.98	0.035	-	0.0033	2.5
10-6	0.46	0.96	0.034	-	-	3.2
10-21	1.5	0.92	0.054	-	-	2.4
10-27	1.4	0.96	-	-	0.0023	1.8
11-3	1.4	0.83	-	0.08	0.0028	1.1
11-10 **					-	1.4
11-16 **					0.0036	1.4
12-5	0.71	0.92	-	-	0.0021	0.58

*Results less than the reporting limit are indicated by a (-).
**Gamma scan lost.
***Not Analyzed

APPENDIX C
TABLE 1 (CONTINUED)

Date	K^{40}	Zn^{65}	Cs^{137}	I^{131}	Sr^{90}	P^{32}
Reporting Limits*	0.3	0.08	0.03	0.05	0.002	0.1
Benton City						
Farm 1						
3-7	1.7	-	-	-	0.0021	Lost
3-31	1.6	-	-	-	0.0028	-
4-27	1.8	-	-	-	0.0051	-
7-13	1.2	-	-	-	Not Analyzed	
7-14	0.90	-	-	-	" "	
Farm 2						
10-19	0.95	-	-	-	-	-
11-16 **					0.0040	-
12-22	1.5	-	-	0.082	0.0021	-
Local Purchase - Commercial Milk						
Brand A						
3-12	1.2	-	0.031	-	0.0042	-
3-30	1.4	-	-	-	0.0051	-
4-28	1.6	-	0.033	-	0.0045	-
5-24	1.4	-	-	-	0.0046	-
Brand F						
3-1	1.4	-	-	-	0.0040	-
3-30	1.2	-	-	-	0.0038	-
4-28	1.6	-	-	-	0.0029	-
5-24	1.3	-	-	-	0.0043	-
7-8	1.2	-	0.030	-	Not Analyzed	
7-13	1.0	-	-	-	" "	
7-14	1.2	-	-	-	" "	
11-1	0.76	-	-	-	0.0031	-
11-8 **					-	-
12-5	1.3	-	-	-	0.0023	-

*Results less than the reporting limit are indicated by a (-).
**Gamma scan lost.

APPENDIX C
TABLE 1 (CONTINUED)

Date	K^{40}	Zn^{65}	Cs^{137}	I^{131}	Sr^{90}	P^{32}
Reporting Limits*	0.3	0.08	0.03	0.05	0.002	0.1
Brand H						
3-1	1.2	-	0.052	-	0.0098	-
3-30	1.3	-	0.044	-	0.0056	-
4-28	1.4	-	0.035	-	0.014	-
5-24	1.4	-	0.043	-	0.011	-
11-3	1.1	-	-	-	0.0093	0.47
11-10 **					0.010	-
12-5	1.3	-	-	-	0.0083	-

*Results less than the reporting limit are indicated by a (-).
**Gamma scan lost.

APPENDIX C
TABLE 2

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN ALFALFA PURCHASED FROM GROWERS AT SELECTED LOCATIONS - 1960

Units of 10^{-6} $\mu c/g$ of Alfalfa

Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95} $-Nb^{95}$	Cs^{137}	Ru^{103} $+Ru^{106}$	I^{131}	Cr^{51}	Ce^{144} $-Pr^{144}$	P^{32}	Sr^{89}	Sr^{90}
Reporting Limits*	0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.1	0.01	0.006
Riverview Irrigation District Pasco, Washington												
4-26	-	7.7	0.20	-	-	-	0.216	-	-	-	Lost	Lost
5-3	0.46	8.8	4.1	-	-	-	-	7.2	3.0	0.20	0.01	0.032**
5-10	0.46	6.4	4.0	-	-	0.58	-	6.4	2.1	0.46	0.030**	0.037**
5-16	0.20	8.8	2.2	-	0.064	-	-	3.1	-	0.15	0.046	0.052
5-24	-	11	-	-	0.11	0.61	-	0.6	-	Lost	0.030	0.053
6-21	0.24	7.5	2.4	-	-	-	-	11	0.62	0.32	Lost	Lost
6-28	0.36	6.8	2.1	-	-	0.66	-	9.2	1.3	0.50	0.031	0.015
7-26	-	7.8	0.64	0.53	-	-	-	3.8	-	0.64	0.011	0.020
8-2	NA**	NA	NA	NA	NA	NA	NA	NA	NA	0.59	-	0.074
8-9	"	"	"	"	"	"	"	"	"	1.8	-	0.027
8-16	0.17	13	0.34	0.13	-	-	-	3.5	-	0.51	0.024	0.15
8-30	-	1.8	1.1	-	-	-	-	7.8	-	Lost	Lost	Lost
9-6	-	7.8	0.46	0.34	-	-	0.14	1.9	-	0.31	Lost	Lost
9-13	0.13	5.8	1.8	-	-	0.98	-	19	1.0	2.6	0.013	0.059
9-20	0.16	8.0	1.3	-	-	-	-	14	-	4.6	Lost	Lost
9-27	0.97	8.9	6.1	0.28	-	2.8	-	87	10	2.6	0.095	0.050

*Results less than the reporting limit are indicated by a (-).
**Not Analyzed.

APPENDIX C
TABLE 2 (CONTINUED)

Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95} $-Nb^{95}$	Cs^{137}	Ru^{103} $+Ru^{106}$	I^{131}	Cr^{51}	Ce^{144} $-Pr^{144}$	P^{32}	Sr^{89}	Sr^{90}
Reporting Limits*	0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.1	0.01	0.006
Riverview Irrigation District Pasco, Washington (Cont.)												
10-4	0.18	5.7	1.4	-	-	-	-	7.9	-	2.1	0.015	0.029
10-11	2.0	9.8	14	0.73	-	1.6	-	60	-	Lost	0.050	-
10-25	-	6.4	0.50	-	-	0.50	0.58	-	-	1.7	-	0.0074
11-1	-	5.6	1.8	-	-	-	-	3.3	-	0.37	Lost	Lost
11-8 **										0.58	0.026	0.050
Ringold, Wash.												
5-10	-	7.8	-	-	-	-	0.1	-	-	-	-	0.022
5-16	-	7.9	3.9	0.12	-	1.4	-	8.4	5.5	1.2	0.018	0.016
5-25	0.25	7.8	2.8	-	-	-	-	2.9	-	Lost	0.019	0.024
6-2	0.23	8.5	2.1	-	0.07	-	-	2.4	-	0.5	-	0.0078
Benton City, Wash.												
5-10	-	4.3	-	-	-	-	-	-	-	-	NC***	0.018
5-16	-	4.1	-	-	-	-	-	-	-	-	-	0.036
5-25	-	5.5	-	-	0.08	-	0.17	-	-	Lost	Lost	Lost
6-6	-	5.5	-	-	-	-	-	-	-	0.13	0.019	0.025
Eltopia, Wash.												
5-10	-	6.8	-	-	-	-	-	-	-	-	-	0.028
5-16	-	6.4	0.5	-	0.05	-	0.11	-	0.53	-	0.011	0.024
5-25	-	6.5	-	-	-	1.1	-	-	0.59	Lost	0.023	0.040
6-7	-	7.4	-	-	0.05	-	0.17	-	-	-	0.044	0.026

*Results less than the reporting limit are indicated by a (-).
**Gamma scan lost.
***NC means analysis not completed at time of report.

APPENDIX C
TABLE 3

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN VEGETABLES PURCHASED FROM GROWERS AT SELECTED LOCATIONS - 1960

Units of 10^{-6} μc/g of Vegetable

Crop	Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95} $-Nb^{95}$	Cs^{137}	Ru^{103} $+Ru^{106}$	I^{131}	Cr^{51}	Ce^{141} $+Ce^{144}$	P^{32}	Sr^{89}	Sr^{90}
Reporting Limits*		0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.1	0.01	0.006
Riverview Irrigation District													
Corn	7-27	0.67	1.1	-	-	-	-	-	-	-	0.60	-	-
Beets	7-28	-	4.2	-	0.49	-	-	-	0.72	-	Lost	-	0.013
Carrots	7-28	-	4.8	0.10	0.48	-	-	-	1.3	-	Lost	-	0.016
Corn	8-10	-	2.1	1.0	-	-	-	-	-	-	0.33	-	-
Tomatoes	8-10	-	1.6	-	-	-	-	-	-	-	-	-	-
Cantaloupe	8-10	-	2.2	-	-	-	-	-	-	-	-	-	-
Cucumber	8-10	-	1.3	-	-	-	-	-	-	-	-	-	-
Corn	8-16	-	2.2	2.7	-	-	-	-	-	-	0.18	-	-
Carrots	8-16	-	4.6	0.14	-	-	-	-	-	-	0.11	-	0.016
Carrots	8-16	-	2.6	0.10	-	-	-	-	-	-	0.12	-	-
Cantaloupe	8-16	-	4.9	0.30	-	-	-	-	-	-	-	-	-
Tomatoes	8-16	-	3.0	-	-	-	-	-	-	-	-	-	-
Peaches	8-29	-	2.1	-	-	-	-	-	-	-	-	-	0.006
Corn	8-29	-	2.3	-	-	-	-	-	-	-	-	-	-
Grapes	9-6	-	3.2	0.10	-	-	-	-	-	-	-	-	-
Watermelon	9-7	-	1.8	0.15	-	-	-	-	-	-	-	Lost	Lost

*Results less than the reporting limit are indicated by a (-).

APPENDIX C
TABLE 3 (CONTINUED)

Crop	Date	Sc^{46}	K^{40}	Zn^{65}	$Zr^{95}-Nb^{95}$	Cs^{137}	$Ru^{103}+Ru^{106}$	I^{131}	Cr^{51}	$Ce^{141}+Ce^{144}$	P^{32}	Sr^{89}	Sr^{90}
Reporting Limits*		0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.1	0.01	0.006
Benton City, Washington and Vicinity													
Apricots	7-1	-	2.8	-	-	-	-	-	-	-	-	-	-
Corn	8-10	-	1.9	-	-	-	-	-	-	-	-	Lost	Lost
Corn	8-10	-	0.97	-	-	-	-	-	-	-	-	-	-
Corn	8-16	-	2.2	-	-	-	-	-	-	-	-	-	-
Cucumbers	8-16	-	1.8	-	-	-	-	-	-	-	-	-	-
Cucumbers	8-16	-	1.7	-	-	-	-	-	-	-	-	-	0.0083
Cabbage	8-16	-	2.3	-	-	-	-	-	-	-	-	-	-
Tomatoes	8-16	-	1.3	-	-	-	-	-	-	-	-	-	-
Pears	8-30	-	3.6	-	-	-	-	-	-	-	-	-	-
Peaches	8-30	-	2.0	-	-	-	-	-	-	-	-	-	-
Barley	8-30	-	5.5	0.13	-	-	-	-	-	-	-	-	0.034
Rye	8-30	-	4.4	0.15	-	-	-	-	-	-	-	0.031	0.051
Wheat	8-30	-	4.2	0.12	-	-	-	-	-	-	-	-	-
Ringold and Vicinity													
Apricots A	7-1	-	1.8	-	-	-	-	-	-	-	-	-	-
Apricots B	7-1	-	2.1	-	-	-	-	-	-	-	-	-	-
Apricots C	7-1	-	2.6	-	-	-	-	-	-	-	-	-	-
Peaches	8-29	-	2.0	-	-	-	-	-	-	-	-	-	-
Corn	8-29	-	1.9	0.21	-	-	-	-	-	-	-	-	-

*Results less than the reporting limit are indicated by a (-).

APPENDIX C
TABLE 4

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN OYSTERS, WILLAPA BAY, WASHINGTON - 1960

Units of 10^{-6} μc/g of Oyster

Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95} $-Nb^{95}$	Cs^{137}	Ru^{103} $+Ru^{106}$	I^{131}	Cr^{51}	Ce^{141} $+Ce^{144}$	P^{32}	Sr^{89}	Sr^{90}
Reporting Limits*	0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.1	0.004	0.002
1-27	-	1.4	40	0.15	-	-	-	0.74	1.3	1.0	-	-
8-9	0.13	2.5	52	-	-	-	-	-	-	0.81	-	0.0026
8-23	0.14	3.0	78	0.95	-	-	-	-	-	0.92	-	-
9-13	0.12	2.6	49	-	-	-	-	-	-	0.43	-	-
9-27	0.11	2.3	53	-	-	-	-	-	-	-	0.0078	0.0083
10-12	-	2.6	58	-	-	-	-	-	-	0.16	-	0.0025

*Results less than the reporting limit are indicated by a (-).

APPENDIX C
TABLE 5

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN COMMERCIAL BABY FOODS

Units of 10^{-6} μc/g of Baby Foods

Kind	Brand	Date	K^{40}	Cs^{137}	Sr^{89}	Sr^{90}
Reporting Limits*			0.3	0.03	0.004	0.002
Cereals						
Barley	A	5-11-60	2.3	0.077	0.014	0.0051
Oat	A	5-11	2.6	-	-	0.0069
Rice	A	5-11	1.6	-	0.0045	-
Protein	B	5-11	9.4	0.085	-	0.014
Protein	B	8-16	8.1	0.064	-	0.056
Mixed	B	5-11	3.0	0.10	-	0.020
Mixed	B	8-16	3.7	0.075	-	0.030
Mixed	C	5-11	2.0	-	0.023	0.0072
Fruits and Vegetables						
Applesauce	A	12-10-59	0.39	-	-	-
Applesauce	A	5-11-60	-	-	-	-
Applesauce Jr.	A	5-11	0.33	-	-	-
Applesauce Jr.	C	5-11	0.83	-	-	-
Banana	A	12-10-59	1.2	-	0.0070	-
Banana	C	5-11-60	0.96	-	-	0.0023
Pears	A	5-11	0.51	-	-	0.0033
Pears	C	5-11	1.2	-	-	-
Pears, Jr.	A	5-11	0.86	-	-	0.0047
Peaches	A	5-11	1.0	-	-	-
Peaches Jr.	C	5-11	1.9	0.033	-	0.0024
Prunes	A	5-11	0.90	-	-	-
Prunes	C	5-11	2.4	-	-	0.0042
Plums	C	5-11	1.1	-	-	0.0027
Green beans	A	12-10-59	0.84	-	-	0.0028
Green beans	A	5-11-60	0.78	-	-	0.0027
Green beans	C	5-11	1.1	-	-	-
Green beans Jr.	A	5-11	0.94	-	-	0.0043
Beets	A	5-11	1.5	-	-	0.0033
Carrots	A	5-11	0.34	-	-	0.0060
Carrots	C	5-11	1.9	-	-	-
Peas	A	12-10-59	0.67	0.61	-	0.0022
Peas	A	5-11-60	0.70	-	-	-
Peas	C	5-11	1.0	-	-	-

*Results less than the reporting limit are indicated by a (-).

APPENDIX C
TABLE 5 (CONTINUED)

Kind	Brand	Date	K^{40}	Cs^{137}	Sr^{89}	Sr^{90}
Reporting Limits*			0.3	0.03	0.004	0.002
Sweet Potatoes	A	5-11-60	1.6	-	-	0.0053
Sweet Potatoes	C	5-11	1.3	-	-	0.0023
Sweet Potatoes Jr	A	5-11	1.8	-	-	0.0070
Squash	A	5-11	1.2	-	-	0.0023
Squash	C	5-11	1.5	-	0.0083	-
Squash Jr	A	5-11	1.0	-	-	0.0023
Spinach	C	5-11	2.0	-	-	0.010
Meat and Poultry Products						
Egg Yolks	C	5-11	0.34	-	-	0.0090
Pork	A	12-10-59	1.8	0.082	-	-
Pork	A	5-11-60	1.7	-	-	0.0037
Pork	C	5-11	1.9	0.073	-	0.0031
Chicken	A	12-10-59	0.82	-	-	-
Chicken	A	5-11-60	0.89	-	-	-
Beef	A	12-10-59	2.0	0.072	-	-
Beef	A	5-11-60	2.0	0.065	-	0.0036
Beef	C	5-11	1.7	0.13	-	0.0041
Beef Jr	A	5-11	1.9	0.12	-	0.0032
Lamb	A	12-10-59	1.6	0.13	0.0040	0.0040
Lamb	C	5-11-60	1.6	-	-	0.0027
Veal	C	5-11	1.8	0.24	0.0045	0.0039
Veal Jr	A	5-11	2.1	0.093	-	-
Tuna	C	5-11	-	-	-	-

*Results less than the reporting limit are indicated by a (-).

APPENDIX C
TABLE 6

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN LOCALLY PURCHASED CONDENSED, EVAPORATED OR FORMULA MILK

Units of 10^{-6} μc/g of Milk

Brand	Date	K^{40}	Cs^{137}	Sr^{89}	Sr^{90}
Reporting Limits*		0.3	0.03	0.004	0.002
J	12-23-59	1.7	-	-	0.0060
	5-6-60	1.2	-	-	0.017
	8-16	1.4	0.047	-	0.0037
C	12-23-59	3.0	0.17	-	0.019
	5-6-60	2.6	0.035	0.013	0.020
	8-16	2.6	0.034	-	0.011
L	12-23-59	2.8	0.13	0.0040	0.012
	5-6-60	4.3	0.23	-	0.031
	8-16	2.5	-	-	0.0075
K	12-23-59	2.7	0.081	0.012	0.015
	5-6-60	2.6	0.050	-	0.014
	8-16	2.6	-	-	0.0087
T	5-6-60	3.2	0.071	-	0.0051
	8-16	2.4	-	-	0.0037
R	5-6-60	2.3	0.082	-	0.032
	8-16	1.7	0.033	-	0.029

*Results less than the reporting limit are indicated by a (-).

APPENDIX D
TABLE 1

IONIZATION CHAMBER MEASUREMENTS OF EXTERNAL "BACKGROUND" DOSE RATE 3 FEET OFF GROUND AT HANFORD (PROJECT TEST LOCATION ROUTE 10, MI. 1.6)- 1960

Measurement Period	Mr/Day	Measurement Period	Mr/Day	Measurement Period	Mr/Day
1/11-1/13	0.38	5/2-5/4	0.36	8/26-8/29	0.30
1/13-1/15	0.40	5/4-5/6	0.35	8/29-8/31	0.30
1/15-1/18	0.41	5/6-5/9	0.34	8/31-9/2	0.32
1/18-1/20	0.42	5/9-5/11	0.33	9/2-9/7	0.32
1/20-1/22	0.43	5/11-5/13	0.33	9/7-9/9	0.35
1/22-1/25	0.44	5/13-5/16	0.33	9/9-9/12	0.38
1/25-1/27	0.45	5/16-5/18	0.33	9/12-9/14	0.36
1/27-1/29	0.42	5/18-5/20	0.32	9/14-9/19	0.37
1/29-2/1	0.41	5/20-5/23	0.35	9/19-9/21	0.33
2/1-2/3	0.39	5/23-5/25	0.35	9/21-9/23	0.40
2/3-2/5	0.37	5/25-5/27	0.35	9/23-9/26	0.37
2/5-2/8	0.38	5/27-6/1	0.32	9/26-9/29	0.41
2/8-2/10	0.35	6/1-6/3	0.29	9/29-10/3	0.42
2/10-2/12	0.36	6/3-6/6	0.32	10/3-10/5	0.41
2/12-2/15	0.34	6/6-6/8	0.32	10/5-10/7	0.38
2/15-2/19	0.40	6/8-6/10	0.36	10/7-10/10	0.36
2/19-2/22	0.33	6/10-6/13	0.31	10/10-10/12	0.40
2/22-2/24	0.42	6/13-6/15	0.32	10/12-10/14	0.35
2/24-2/26	0.38	6/15-6/17	0.31	10/14-10/17	0.42
2/26-2/29	0.41	6/17-6/20	0.31	10/17-10/19	0.48
2/29-3/2	0.43	6/20-6/22	0.32	10/19-10/21	0.45
3/2-3/4	0.42	6/22-6/24	0.36	10/21-10/24	0.39
3/4-3/7	0.33	6/24-6/27	0.30	10/24-10/26	0.37
3/7-3/9	0.36	6/27-6/29	0.31	10/26-10/28	0.37
3/9-3/11	0.38	6/29-7/1	0.31	10/28-11/2	0.41
3/11-3/14	0.39	7/1-7/6	0.32	11/2-11/4	0.39
3/14-3/16	0.36	7/6-7/8	0.32	11/4-11/7	0.51
3/16-3/18	0.38	7/8-7/13	0.29	11/7-11/9	0.42
3/18-3/21	0.39	7/13-7/15	0.30	11/9-11/11	0.48
3/21-3/23	0.42	7/15-7/20	0.29	11/11-11/14	0.41
3/23-3/25	0.38	7/20-7/22	0.32	11/14-11/16	0.33
3/25-3/30	0.36	7/22-7/25	0.32	11/16-11/21	0.35
3/30-4/1	0.34	7/25-7/27	0.33	11/21-11/23	0.45
4/1-4/4	0.35	7/27-7/29	0.34	11/23-11/28	0.39
4/4-4/6	0.38	7/29-8/1	0.32	11/28-11/30	0.44
4/6-4/8	0.38	8/1-8/3	0.30	11/30-12/2	0.46
4/8-4/11	0.36	8/3-8/5	0.30	12/2-12/5	0.35
4/11-4/13	0.37	8/5-8/8	0.32	12/5-12/7	0.46
4/13-4/15	0.33	8/8-8/10	0.33	12/7-12/9	0.43
4/15-4/18	0.38	8/10-8/12	0.31	12/9-12/12	0.46
4/18-4/20	0.34	8/12-8/15	0.32	12/12-12/16	0.46
4/20-4/22	0.34	8/15-8/17	0.31	12/16-12/21	0.38
4/22-4/25	0.35	8/17-8/19	0.30	12/21-12/23	0.43
4/25-4/27	0.35	8/19-8/22	0.32	12/23-12/28	0.46
4/27-4/29	0.35	8/22-8/24	0.32	12/28-1/3/61	0.33
4/29-5/2	0.35	8/24-8/26	0.27		

APPENDIX E

ANALYTICAL METHODS

1. Water Analyses*

All water samples are analyzed for alpha emitters, beta emitters, and selected radionuclides. Alpha emitters are extracted with diethyl ether from 9 N nitric acid. The gross alpha activity is measured with a zinc sulfide (ZnS) scintillation counter. Gross beta activity is determined by evaporating a sample to dryness and counting the residual salts on a gas-flow proportional beta counter operated in the Geiger region.

Rare earths plus yttrium, silicon-31, iodine-131, phosphorous-32, strontium-89 and strontium-90 are measured by beta counting after chemical separation. The rare earths are isolated as a group by hydroxide, fluoride, and oxalate precipitations; silicon is precipitated as the dioxide; iodine is isolated by carbon tetrachloride extraction and precipitation as silver iodide; phosphorous by extraction of phosphomolybdic acid with butanol in diethyl ether or by direct precipitation as the phosphomolybdate; and strontium by successive precipitation of the nitrate and the carbonate. Yttrium-90, separated from the strontium after secular equilibrium is established, is measured to determine strontium-90. Beta decay curves are extrapolated to sampling time to determine the initial activity levels and to check separation effectiveness.

Manganese-56, zinc-69 and gallium-72 are determined by measurement of their characteristic gamma peaks with a multichannel gamma energy spectrometer using a 3 inch x 3 inch thallium-activated sodium iodide (NaI(Tl)) scintillation crystal detector. The measurements are made after the following chemical separations; manganese by precipitation as the dioxide, zinc by precipitation as the phosphate and ion exchange purification, and gallium by extraction with iso-propyl ether and precipitation as the hydroxide. Sodium-24, neptunium-239, chromium-51 and cobalt-60 are also determined using a multichannel gamma energy spectrometer, but are determined from a direct count of residual salts from the evaporated sample, without chemical separations. However, it may be necessary to chemically separate neptunium-239 and cobalt-60 for samples with low concentrations.

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* L. F. Lust. Radiological Chemical Analysis Operation, General Electric Company, HAPO, Private Communication.

Copper-64 is determined from gamma-coincidence counting measurements of the annihilation photons produced by positron emission. Scandium-46 is measured by gamma-coincidence counting of the 0.885 Mev and 1.12 Mev photons.

Arsenic-76 is determined from the counting rate of its 2.97 Mev beta. Particles of lower energy from other beta emitters are shielded out by use of a 504 mg/cm^2 absorber.

Uranium concentrations are determined with a fluorophotometer, using standard techniques.

2. Vegetation and Produce Analyses*

Samples of native grasses (vegetation samples) are analyzed with a multichannel gamma energy spectrometer for selected radionuclides. The spectrometer utilizes the 3 inch x 3 inch NaI(Tl) scintillation crystal used in analyzing water samples. These analyses are conducted for 150 gram samples which have been shredded and placed in a 9-ounce glass jar. Background analysis includes the effects of the jar glass which contains minute amounts of radioactivity. There is no ashing or chemical separation performed on vegetation samples.

Farm products, including milk, are analyzed for several radionuclides including those measured in vegetation samples. Increased sensitivity is achieved in produce analysis by using a 9-inch diameter well-type NaI(Tl) scintillation crystal as the detector of a multichannel gamma energy spectrometer. In addition, the analysis includes a determination of the radiostrontium and radiophosphorous after chemical separation. The chemical separation for radiostrontium analysis is performed in the following manner:

> Barium and strontium carriers are added to 500 g samples of produce and 1000 g samples of milk. The produce samples are then ashed at 500-650°C from four to six hours and the ash dissolved in nitric acid. The milk samples are passed through a Dowex 50 x 8, 50-100 mesh Na+ form resin column to separate the anion and cation fractions. Alkaline earths plus some other

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* L. S. Kellogg. Radiological Chemical Analysis Operation, General Electric Company, HAPO. Private Communication.

cations are eluted with dilute nitric acid. The alkaline earths are then precipitated from all samples as carbonates. Strontium and alkaline earth metals are precipitated with fuming nitric acid. Calcium is separated by washing with acetone. Strontium and remaining alkaline earths are dissolved and reprecipitated with fuming nitric acid. The rare earths are removed from an aqueous solution of the nitrates by a $Fe(OH)_3$ precipitation and barium is removed as the chromate. Strontium is precipitated as the carbonate and then dried in a one-inch stainless steel counting dish to constant weight. The strontium mixture is counted for one hour in a low background (anti-coincidence) gas-flow proportional beta counter.

Strontium-90 is allowed to reach secular equilibrium with its daughter, yttrium-90, which is then extracted with buffered TTA. Yttrium-90 is counted in the same manner as the strontium mixture. The strontium-90 content is calculated from the yttrium-90 counting rate, and the strontium-89 content from the difference in counting rates of total strontium and strontium-90.

The chemical separation for radiophosphorous is performed on samples of sufficient size to yield 40-50 mg of phosphorus.

The sample is wet ashed with nitric acid. Phosphorous is precipitated from the acid solution as ammonium phosphomolybdate. This precipitate is dissolved in ammonium hydroxide, ammonium citrate is added to complex most of the remaining interferring elements, and the phosphorous is precipitated as magnesium ammonium phosphate. After dissolving the precipitate in hydrochloric acid, ammonium citrate is again added and phosphorous is reprecipitated as magnesium ammonium phosphate.

The precipitate is dried in a 1-1/2 inch stainless steel counting dish under heat lamps and counted over a period of two weeks in a gas-flow, proportional beta counter.

3. Air Sample Analyses

Air-borne concentrations of radioactive materials are measured principally by Iodine-131 scrubber samplers. These samplers consist of a calibrated, electrically-driven vacuum pump which draws 2.0 cfm (3.4 m^3/hr) of air through one liter of 0.1 normal NaOH solution. A balancing platform and siphon arrangement permits introduction of distilled water into the scrubber at a rate equal to the rate of evaporation. This water feeder helps maintain constant liquid head, air flow rate, and scrubber efficiency.

After one week of operation, the scrubber bottle is replaced and taken to the radiochemical analysis laboratory for determination of the iodine-131 content. The analytical procedure used provides for the addition of an iodine carrier and $AgNO_3$ to the scrubber solution, followed by filtration of the resulting silver iodide precipitate. The radiation from the iodine-131 on the filter is measured by an end-window GM tube connected to a scale-of-64 scaler. Atmospheric concentrations of iodine-131 are then calculated from these counting rates by applying factors for counter calibration, chemical recovery of the iodine-131, scrubber efficiency and the volume of air sampled.

Measurements for concentrations of radioactive particulates in the atmosphere are made with 2 inch x 4 inch HV-70 filter paper in conjunction with Motoaire filter samplers. The filters are changed on either a daily or a weekly schedule and then are autoradiographed using Eastman Kodak, Type-K, X-ray film. The filters are placed in direct contact with the film for one week, the filter is removed, and the film is developed. The developed film is viewed on a standard X-ray viewer and each image produced is counted as one radioactive particle. Air-borne concentrations of radioactive particles are calculated by dividing the number of images obtained per filter by the total volume (nominal 2.5 cfm) of air sampled.

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